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Foote

ECONOMIC VALUE

—OF—

Electric Light and Power.

ECONOMIC VALUE

OF

Electric Light and Power.

Gen Ripley.

BY

A. R. FOOTE,

CINCINNATI, O.

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PREFATORY.

REASONS FOR WRITING THIS BOOK.

I thought it necessary that some things should be said for the electric industry in the interest of those who are, or should become, users of Electric Service.

I felt that I could say those things. This made it my duty to say them.

Now that I have said them, it will quickly appear that there are those who can say them better than I have done; also, that there are others who are not in accord with what I have said. Both classes of critics are aware that in our day of civilization there is no monopoly of the expression of thought, therefore I have a reasonable hope that in due time I shall hear from them freely and fully.

I design this book to be of service—

1st. To those who are interested in obtaining state or municipal legislation. Such legislation should place the *Electric Service* of a city on the basis of a *Public Improvement*, entitled to special privileges, in order to secure the service for users, on terms and under economic conditions best calculated to properly serve the interests of all citizens.

2d. To those who are, or are about to become, interested in Electric Central Stations, and desire to increase their facilities until they realize the full possibilities of their opportunity. To do this, they need assistance in creating a correct public opinion regarding their undertaking; in guiding the action of Municipal Authorities; in securing Customers; and in interesting Capitalists, on whom they must depend for the means with which to develop their industry.

3d. To manufacturers, to assist them in opening new fields for the use of their apparatus, and extending its use where a beginning has been made.

With these objects in view, I have made no reference to any inventor, system, or manufacturer, by name, in a way to render the book less useful to one than to another. The Electric Industry comprehends all workers in its department of effort.

I have made no reference to Storage Batteries, for the reason that their possibilities are so great, the progress being made in their development and application to practical uses is so marked, and their economic value so special, I consider their department of the subject worthy of special treatment.

At the suggestion of my publishers I requested *Allen V. Garratt*, Secretary and Treasurer of the National Electric Light Association, to write an appendix of "*Mechanical and Electrical Terms Explained in Untechnical Language*," for the benefit of unprofessional readers, I have endeavored to exclude technical terms as much as possible from the text of the book.

Believing as I do, that money spent for education is put to its highest economic use, I feel it be to right to ask the attention of every reader to the advertisements of Electrical Publications. They are the true Banyan Trees of the Electric Industry.

My presentation of the economic possibilities of Electric Light Power is not a prophecy; it is not even a vision; it is the practical outcome of that which is. Pledged to its realization, seeds of promise are already thickly planted throughout the civilized world.

To show the basis of my representations, I have gathered, at random, a few leaves from the fast-spreading Banyan Trees of Electrical Knowledge. Among them will be found some facts—firmly fixed as are the rock base of mountains; and some fancies, ephemeral "as a whiff of rifle smoke upon the mountain air."

I believe the true functions of government to be *to regulate and control, not to own and operate,* commercial industries. In considering this branch of the subject, I have used the phrase, "Commercial Monopolies," as one best calculated to arrest attention and induce discussion.

As it is more necessary for representatives to be popular than wise, politicians are not the best teachers for the people. There are indications that the desire to be popular is leading many politicians to favor measures which are the embodiment of economic unwisdom. To illustrate this, I have made selections from economic discussions which, otherwise, would not have found a place in this book.

The Economic Value of Electric Light and Power can not be developed to the point of greatest benefit to the users of Electric Service, by inventors and manufacturers alone. The realization of the advantages of Electricity by the people now depends more largely upon the economic conditions fixed for its *Production and Distribution* by state and municipal legislation than upon any other factor in the problem.

Many choice seeds are sheathed in prickly husks; many pearls of great value are hidden in unlovely shells. Through our effort to possess them, our appreciation of them is developed.

The same conditions govern thought. An idea, a truth, can not be expressed without its attendant husk, or shell of words, or design.

Those who read this book will find in it much which, to them, may be only a rubbish of words. If in this rubbish they find one seed, one pearl—an idea or a truth—that is of value to them, let them take *that*, and cast all the rest aside. Let that one sentence be to them, my word of truth—my book.

"Take the goods the gods provide, and make much of them, for they are rare.'

March 11, 1889. A. R. F.

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ELECTRICAL PUBLICATIONS.

ELECTRIC LIGHT AND POWER.

PART I.

THE ELECTRIC SERVICE OF A CITY

Light and power are the foundation necessities of civilization.

Every improvement gained in using material or forces for these services, to produce them cheaply, distribute them safely and cheaply, and use them safely, cheaply and conveniently, has been heralded as the incoming of a new era of greater prosperity for those who obtained the benefit of such advantages.

To appreciate how fully the promised prosperity has been realized, picture to the imagination what the *present* condition of any city would be had it never used any other method of illumination than the tallow-candle, and no other mechanical power than that derived from the water-wheel or other more primitive methods.

Having that picture in mind, not even a suggestion is needed to show that all improvements in methods in producing light and power have been wealth producers. The contrast between communities enjoying such advantages and those who do not, shows so strongly the increase of wealth possessed by the former that there is no room for doubt on this point.

Such improvements have cost individuals and communities large sums, but they have produced more than they cost. It has been cheaper to have them than to do without them. This fact can not be questioned. The isolated cases of failure, impractical experiments or poorly-calculated investments, are but the sacrifices by which the general good has been gained.

So much has been done in applying Electricity to the uses of light and power that the following statement of some of its possibilities is no longer prophetic.

Electric light and power will produce more changes in the mechanical servants and conveniences of civilized life than has ever been caused by the use of any other method or force which has been subjected to the service of man.

The uses of Electricity are limited only by the want of intelligence in producing fitting apparatus for its application. The demand for such apparatus is limited only by the want of intelligence on the part of the public to know how to use it properly.

So rapid has been the development of the electric industry, few have been able to keep trace of its achievements, and fewer still have sounded its possibilities for the purpose of giving direction to its growth.

It is now known to be practicable to distribute from one central station all the light and mechanical power used in any city. Not only this, the light and power can be delivered to any point in the city; and more important still, it can be divided, and delivered in any quantity needed.

From the same central station, from the same generator in the station, if need be, accompanying each other over the same conductor—as it were one spirit with two forms of expression—the Electric current places at the command of the poorest member of society the two basic requirements of civilized life—light and power. They come without noise, without heat, smoke, dust or dirt of any kind. They consume no oxygen from the air; they bring no poisonous gases into rooms; they destroy no property; they make life more healthful, comfortable, and freer from liability to accident; they are brought into use without effort; with silent, patient energy they wait the will of their employer.

But turn a key, and light appears where the sun can not shine.

But turn a key, and the tireless energy of the universe will play alike with the smallest toy or the heaviest machine.

Did civilization advance when a machine gave partial liberty to the slave who sang the "Song of the Shirt?" How much more shall civilization advance when that same slave gains the greater liberty of having light with which to see to work, and of having the mechanical force required to operate that same machine come to her in an electric current through a small flexible wire?

Comply with its conditions, and then but turn a key, and the servant of all life will be present in light and power.

ELECTRIC LIGHT.

In the year 1870 there was not one Electric light in use in the world. Now they are in use in every civilized country,

It is estimated that 300,000 Arc lamps and 3,000,000 Incandescent lamps are in use daily in the United States.

While those bound to the old civilization by invested interests are endeavoring to stay the progress of events by plying people's fears with "bugaboo" stories about the "deadly wires," the unprogressive government of Spain has been "struck by lightning," and has decreed, *as a measure of public health and safety* (under penalty of not being allowed to open their doors, if the order is not complied with) that every theatre in the kingdom must be illuminated by Electricity by October 31, 1888.

THE ARC LAMP.

In the order of development the Arc lamp came first. It gives an enormous production of light at one point.

The principal efforts in its development have been to subdivide it, secure steadiness in its burning, and reduce the power consumed in its production.

Progress has been made in these particulars to such an extent that it is no assumption to say that the best of Arc light apparatus will produce the cheapest and most satisfactory light in the world for all places where its use is desirable. It is used principally for broad or closely-built streets, large spaces, such as railroad yards, saw and planing mills, warehouses, docks, brick-yards, breweries, large salesrooms, manufacturing establishments, etc., etc.

Arc lamps are usually furnished in *800, 1,200 and 2,000 candle power for ordinary purposes, while much more powerful lamps are provided for special uses.

On account of the high tension necessarily used in the production of the Arc light, it has always been easy to distribute these lamps over large areas. They can be supplied, on an economical basis, ten or twelve miles distant from the generating dynamo.

THE INCANDESCENT LAMP.

The Incandescent lamp is a later production than the Arc lamp, and is of far greater importance. Its invention has marked an era in the history of Electric lighting. The principal efforts in its development have been

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* See Appendix.

to cheapen the lamp, prolong its life, increase its size, measure the current it consumes, and to increase the distance from the generating dynamo at which it can be furnished on an economical basis.

To write a description of all that has been done in these efforts to render the Incandescent lamp the domestic servant it now is, would fill volumes. The results of these efforts can be summed up in a few words.

Incandescent lamps are now furnished of different sizes, from 16 candle power to 150 candle power. Their average life is from 800 to 1,500 hours, actual burning.

For a long time the general adoption of the Incandescent lamp was held in check by the size, and consequently the cost, of the copper conductors required for its low tension current. The difficulties of distribution for the Incandescent lamp have been entirely overcome. There are a number of stations in the United States that are furnishing these lamps, on an economical basis, five miles distant from the dynamo. The service could be rendered at still greater distance, if desirable.

Another drawback to the general introduction of the Incandescent lamp has been the want of a simple and reliable meter to measure the current consumed by it, as a basis for the charges for its use. On account of its character its use is essentially that of the gas-burner or oil-lamp.

Users of such lights require a lamp that they can use whenever they need it, and one for which they will not have to pay when it is not in use. This requirement is especially essential in domestic lighting, where there can be no regular hours for the use of the lamps, many of which, in certain rooms, would be used only occasionally.

To overcome this difficulty, a meter has been invented, and is now in use, by which the current consumed by Incandescent lamps is measured in ampere hours. Its measurements are based upon the quantity of current required to burn a sixteeen candle power lamp at its full rated capacity. A sixteen candle power lamp is the photometric equivalent of a five foot gas burner; a five foot gas burner is one that will burn five feet of gas in one hour. It will therefore require 200 hours for a five foot burner to consume 1,000 feet of gas. If gas is $2.00 per 1,000 feet, it costs *one cent* to use a five foot burner one hour. If the Electric light is sold by this meter measurement, at *one cent per ampere hour*, the cost of the Electric light will be the same as the cost of gas at $2.00 per 1,000 feet. Helped by this explanation, it will be easy to calculate what the cost of the Electric light should be to meet the cost of gas at any other figure.

This meter is so simple, and so perfect in its action, that any person can learn to read it easily and can as easily satisfy himself as to its accuracy.

This power of distribution and measurement removes the only barriers which have arrested the progress of incandescent lighting.

These lamps are now used on shaded and curved streets, in stores, offices, and other places of business, for theatres, halls and churches, and for residences. They are capable of displacing gas and coal oil. Where quality of light, health, comfort and safety are considered, they are preferred as a matter of economy, especially as they are susceptible of being used in many ways not possible with any other method of illumination.

With such advantages, a combined system of Arc and Incandescent lighting can furnish better illumination at no increase in cost, over that furnished by any method of lighting heretofore in use. In fact, the quality of the light, and the conditions under which it is furnished, is as much superior to gas as gas is superior to coal oil, or as coal oil is preferable to tallow candles.

With such a system the entire lighting of a city can be done, both public and private, and an immense gain secured in the health and comfort of the people.

ELECTRIC MOTOR POWER.

The Electric light has so dazzled the minds of men with its brilliant possibilities, they are hardly able to look beyond it to consider the greater possibilities of Electric Motor Power.

A new acquisition of the use of mechanical power has always marked an advance in civilization. The degree of advance made is always limited by the power to produce *and distribute* the new force cheaply.

Much has been written about "the age of steam;" the age of Electricity is next in order.

One general principle, expressing a law of nature, runs through every development in all departments of industry or thought.

That which experience has proven true, in one condition, serves as the foundation on which the next condition of development must rest. When steam as a power was brought into use, every mechanical principle, that had been proven true by the use of other forms of mechanical force, was used as the basis of the development of this new agent of power.

The advent of a new force has never completely abolished the use of the old. In fact, the new is developed by making the old its servant. Water became the servant of steam. Water and steam are the servants of Electricity.

The dynamo, the generator of electric force, is dependent for its operation on some other force, such as wind, water, or steam. The Electric Motor, the expression of electric force, is dependent for its operation on the dynamo.

A force is known by its highest form of expression. Water power is mentioned without reference to the power of gravity. Steam power is referred to without reference to the expansive power of water or heat. Electric power is also spoken of without reference to its underlying forces. It is vitalized by all power. It is the spirit of all force.

The limit on the benefit derived from the use of any force is fixed by the power to distribute it cheaply. Of the two factors, the power to *distribute* cheaply is far more potent than the power to *produce* cheaply.

To illustrate this statement, water power may be taken as the cheapest method of producing power. The distribution of power so produced has never been effected except for very small areas; for this reason all the benefits derived from water power have been concentrated at the points where it was produced, and has given to such points great industrial supremacy.

Steam power, though more expensive to produce than water power, has been vastly more beneficial *because it can be produced at more points.* This, in a certain way has answered the requirements of distribution. Like water power however, no distribution of steam power has ever been effected, except for very small areas around the place of production. This has caused a concentration of benefits in places where cheap water and fuel can be obtained for the production of steam. Following the law of concentration of energy, steam is produced cheapest when it is produced in largest quantity. Its production in large quantities has benefited only a few who have been able to produce and use it in this way, because the power when produced could not be distributed.

As the freedom of the spirit is greater than the freedom of the body, so is the distribution of Electric power freer than that of all other forms of force. It is their spirit.

What limits may be found on the practical distribution of Electric power is not known. Conditions for its distribution are being learned. When the natural laws governing it are complied with in these conditions, it is known that the world is not large enough to limit its distribution.

What does this mean? Simply this: That instead of having a large number of comparatively small steam plants scattered over a city, each costing a considerable investment, each attended with its expense for water, fuel, and other material, also for its fireman and engineer; each with its attendant noise, smoke, dust, dirt and rubbish; each with its attendant risk of injury or loss to property or life, by fire or explosion; instead of all these centres of disturbance, smutch or danger, there will be but one, and that one removed from the central part of the city.

From one station, power can be delivered to operate all the machines, for all mechanical work, and to operate all the street cars in a city. To accomplish this, two systems can be used—one using large motors to operate all the machines in a shop, from lines of shafting, exactly as the steam engine is used; the other is to connect

THE INTERESTS OF THE CITY AND ITS CITIZENS.

It is apparent that the development of the Electric service of a city can not be accomplished without the co-operation of the corporation with its citizens.

The terms of the privilege granted by the corporation, the conditions fixed for the construction of lines, and the support given by its patronage; all have a vital bearing upon the enterprise.

By granting but one privilege for an Electric Central Station Company; by making no conditions as to construction, except those suggested by competent electrical engineering; and by supporting the enterprise with its public patronage, a city can so arrange conditions as to secure for itself and its citizens all the advantages of Electric service known to science. Those advantages have been fully stated. Their desirability can not be questioned. No citizen can truthfully say they will not be of immense benefit to the community as a whole. The Electric industry touches and serves all interests.

Unlike the great steps of progress made by the improvements which have preceded it, the Electric service finds no unoccupied territory. When water power, steam power, railroads, telegraphs, telephones, and illuminating gas made their respective advents, each entered upon a territory never before occupied in a similar way. The Electric service is destined to gather unto itself the strength of invested conservatism from all these interests, and apply it to the enterprise of a new era of progress.

The question of securing a comprehensive and efficient Electric service for a city can not be confined to the narrow limits of "Gas *versus* Electric Light." It is a question of Progress *versus* Retrogression. For a community to cease to keep in the line of progress is to cease to grow. Cessation of growth is death.

If all the obstructions that have ever been placed in the way of any step of progress were rolled into one, and placed in the way of the advent of Electric light and power, it would be impotent to very much hinder the progress of the inevitable.

Those who have investments likely to be disturbed by the development of the Electric service can choose between investing their surplus in the new life, and thus carry enterprise forward for a new generation, or remain wedded to the past. There is no hardship in this. The community gave them their opportunities gladly and generously. The community is right in looking to them to lead the movement, gladly and generously, which shall give to it, its opportunity, and thus assist it in taking its noblest step of progress. If they will not do this, then they must not question those who occupy the places they ought to make their own.

That city is most prosperous which employs in its own industries the capital and labor of its citizens to the best

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accustomed to them, have learned their value, and would now oppose parting with them much more earnestly than they objected to their coming. They are a part of the stock of *advantages* which the city offers to the stranger to come and make his home within its corporate limits.

The things that are being done every day in these departments of Electric service, with which people have become familiar, were once thought to be more visionary than any of the above statements regarding the Electric light and power service are now thought to be by those who are moderately informed regarding them.

Like all other things, the industry of Electric light and power service has had its day of small beginnings. At first it could not do all of which it is now known to be capable. It has been restricted by the imperfect development of its own apparatus; the opposition of invested interests, which were likely to be displaced by it, and the want of capital to give it its largest and best expression. The day of small undertakings is rapidly passing away. The demonstration is now complete, that all the illuminating and power service of a city can be performed from one central station. Every consideration of economic advantage requires that it shall be done.

Every argument that has been used in favor of distributing the means of illumination from the central station of a gas plant can be urged with greater force in favor of the distribution of Electric lighting from a central station.

Every argument that has been used in favor of improving any water power, with the view of increasing its industrial value, can be urged with greater force in favor of the distribution of power from an Electric central station.

Every argument that has been used in favor of improving navigation, or building railroads to procure cheap fuel, with which to produce cheap steam power, can be urged with greater force in favor of building a large Electric central station, from which to distribute all the light and power required in a city.

If thought is sent over the field of public improvements it easily finds numberless instances where nearly the whole population of a city has gone wild with excited enthusiasm over the prospect of gaining some one of these advantages. Such enthusiasm was not mis-directed. It was absolutely necessary that the city should possess the advantage sought or lose its place in the line of progress. That, it could not afford to do; let it cost what it must, the advantage had to be secured. Secured it was, and though it cost much, its benefits have been far beyond its cost.

Some cities pride themselves on being "the best lighted city in the world." That says much, but when examined into, it means very little. It simply means that a few Arc lights have been secured for the streets, and the people are dazzled by their brilliancy. There is not a city in which its Electric plant is capable of supplying one-twentieth of the illumination in daily use. As for the Power service, that is just being entered upon.

Now that the possibilities of an Electric central station can be placed before a community, with a responsible guarantee of performance, the self-interest of the community will at once demand all the advantages from its Electric service, which science has demonstrated to be practicable.

Until now, an improved method of lighting has been a sufficient inducement to secure the grant of privileges and investment of capital. So striking has been the development of this one feature of the applied uses of Electricity, it has absorbed attention to such an extent that but few are acquainted with its greater use as a distributor of power.

When the value to a community, of the distribution of light and power from an Electric central station, is once fully known, there can be no question as to the character of the Electric service which the community will demand.

The requirements for the Electric service of a city may be formulated as follows:

1. *The apparatus used must be capable of supplying a light, Arc or Incandescent, at any point in the city where a light is needed.*

2. *It must supply the Incandescent lamp by meter meas-*

urement, so that payment is made for the lamp when in use only.

3. *It must supply Motor power in such quantity as needed at any point in the city where wanted for manufacturing or other mechanical purposes.*

4. *It must supply Motor power for operating the street cars of the city.*

Having these requirements in mind, two duties of equal importance impose themselves upon the community:

1. *To obtain a guarantee from the company to whom it gives the privilege of erecting and operating an Electric central station, that it will supply a plant capable of performing all the service required.*

2. *To grant the privilege to but one company, and eliminate from the grant all needless restrictions.*

To show how far from meeting these requirements existing stations are, it may be stated that the whole number of stations erected by two of the principle manufacturing companies is 302, having an aggregate capacity of 584,940 sixteen candle power Incandescent lamps, an average of 1937 lamps per station. Of the 302 stations, 149—nearly one-half—have a capacity of less than 1,000 sixteen candle power lamps. When it is considered that a low estimate for light actually used, is one lamp per person, *for the whole population,* it will be realized how far short these stations are of supplying the whole illuminating requirements of a city.

These are Incandescent light stations. To bring them up to the requirements of performing the entire Electric service of their city, their capacity must not only be increased for Incandescent lighting, but there must also be added to their capacity, apparatus for Arc lighting and Motor service. Where there is more than one Central station in a city, that the best interests of the community will be served by combining them in one, there can be no question. It is true there are some attractive theories regarding the advantages of competition in business. But to perform the Electric service of a city as it should be done, and to secure the community the best advantages of science, mechanically, electrically, and economically, there can be but one ownership, one responsibility for the service; one central station, from which all distribution is made. In great cities several stations may be needed. Each would have as much service to perform as would be required for the entire service of an average sized city. In such cases there should be but one ownership and management. The stations should be erected with reference to each other, so that one could help perform the service of another if required.

It will at once be conceded that the greater the service rendered from one station the cheaper it can be performed. The larger the capital required, the smaller the net profit needed to justify its investment. This is easily illustrated. A small gas plant, furnishing gas at

$2.00 per 1,000 feet but barely makes a living. The investment may be $20,000. If it nets 15 per cent. it makes but $3,000 to be divided between several persons, giving but little to each. Another plant in a large city may furnish gas at $1.00 per 1,000, one-half the price of the smaller company. The investment may be $2,000,000. If it nets 10 per cent., but two-thirds as much as the small company, it will divide $200,000 among its stockholders. This illustration should be convincing as to the policy of granting a franchise to more than one company.

On the point of eliminating from the franchise all unnecessary restrictions, a few words may be said with profit. Those who attempt to fix the requirements are usually not well posted in Electrical engineering, and more frequently render the construction less safe, efficient and ornamental than otherwise, by their attempt to legislate on the subject. Every requirement of sound business management demands that those who build for an investment, shall use only the best apparatus and material for its purpose, and shall construct in the most durable and artistic manner.

The greatest stumbling-block met with, is the question of overhead wiring. The sentiment against it comes from two sources. The ungainly appearance of the overhead construction, put up when there was no experience to guide those doing the work. Overhead wiring is now done in a style to prevent the least possible objection to its use. The second source is from those who seek to protect their own invested interests, by compelling their new competitor to commence business under conditions as nearly prohibitory as possible. To illustrate this, take the estimate for an Arc light plant of 750 lamps. With 75 miles of wire underground, it will cost $435,230. The same plant, with 75 miles of wire overhead, would cost $276,600—a saving in cost in favor of the overhead system of $158,630.

If the citizens of a community, appreciating all the advantages of Electric light, were assured they could secure the service as a free gift—that is, without any increase in the expense already being paid for illumination—how quicky would they take the corporate action to grant the necessary franchise!

If the citizens of a community were assured they could secure the free gift of a splendid water power for their city, how gladly would they vote it an exclusive privilege, knowing well, if ever secured, it must have an exclusive privilege; for, having one, there would be no room for, nor any need of, two.

If the citizens of a community were assured they could secure the free gift of a method of distributing steam power to any point where power was needed in their city, and under conditions making the cost to the consumer, all things considered, less than the power he is now using, how eager they would be to obtain the industrial improvement; how jealously would they guard against restricting the privilege in a way to prevent them from securing it to their own best advantage.

Gather these three great advantages into one, add to this the consideration that, for every light used, for every engine operated, a separate fire is now built, with its attendant risk, smoke. dust, dirt, poisonous gases and consumption of oxygen, and some idea can be formed of the grand step of progress, the munificent benefaction, that will be conferred on a community by those who furnish it with a complete Electric service, competent to fulfill these practical requirements. If the community is but willing, these advantages can be obtained without increase of present expenses for similar services.

To obtain the best service at the least cost, three essential conditions must be complied with:

FIRST—AN UNDIVIDED DEMAND.

SECOND—AN UNRESTRICTED PRIVILEGE.

THIRD—PERMANENT INVESTMENT.

ECONOMIC VALUE OF ARC LAMPS FOR STREET LIGHTING.

It is impossible to obtain reliable statistics on the important item of municipal expense covering the cost of street lighting. Such statistics have little scientific value, for the reason that those who collate them or quote prices do not take into consideration all of the factors in the problem. The most usual omission is a failure to state how many hours of service are rendered for the price paid.

There are three principal lighting schedules in use:

1st. Dark of moon, and until 12 P. M., 937 hours per year.

2d. Dark of moon, and until daylight, 2,024 hours per year.

3d. From dark until daylight, every night, 4,000 hours per year.

There are numerous devices for securing the service when needed, and practising economy at the same time, by stipulations to have the lights burned until 2 or 3 o'clock A. M.; to have them burned during cloudy weather in the light of the moon, and during the dark of the moon, or when ordered by the mayor, or some other official.

It will be seen at once that unless the hours of actual burning are stated, all quotations of price, for the purposes of economic data, are misleading or meaningless. In schedule No. 3, there are more than four times as many hours of service as there are in schedule No. 1. Even this does not express the full difference. Until about 10 P. M., street lighting is assisted in a very marked way by the lights in use in business places and residences. In fact, on some streets, the private lighting is so general the street lighting would not be missed if not in service. After 10 P. M., there is an entire change in these conditions. Most of the private lights are then out, and from that time until daylight, the street lights are depended upon exclusively. It is then that they are most required and do best service. For this reason the actual value of schedule No. 3 is five times that of schedule No. 1, and about 2¼ times that of No. 2.

If service is paid for pro rata on this basis, and a standard 2,000 C. P. arc lamp costs $40.00 per year on schedule No. 1, its price would be $110.00 on schedule No. 2, and $200.00 on schedule No. 3. If figured the other way, and the price of a standard 2,000 C. P. arc lamp is $120.00 per year on schedule No. 3, it should be $53.33 on schedule No. 2, and but $24.00 on schedule No. 1.

The fact is, prices can not be fixed in this way on account of the operation of the economic law, which always reduces cost when service is concentrated or continuous.

It is much more profitable to operate a plant all night and every night at a low rate per hour than to operate it for any fraction of the time at a higher rate.

Any company would prefer to operate its plant 4,000 hours at 3 cents per hour per lamp, to operating it 937 hours for 6¼ cents per hour.

Quality of service must be considered as well as cost. Any observer of industrial operations is familiar with the difference in efficiency and reliability between men employed continuously and for regular hours, and those employed intermittently, as men would be whose employment depended upon the changes of the moon, or the clouds in the sky. For this reason, those who contract for constant service are more satisfactorily served than those who do not, and all disputes as to the time when service should be performed are eliminated from the transaction. This fact has a place and value in the problem of economy in street lighting.

It is urged by some, however, that the gain in economy, by reason of constant service, is more than overbalanced by the fact that the light is not needed after the "noon of night," and that it is in fact more economical for a city to pay the higher rate per hour, for the less number of hours, than to pay the lower rate for the larger number of hours. This is true, if a fact. It is based entirely on the assumption that street lighting is not necessary at certain hours, usually from 1 A. M. until daylight. The fallacy of this assumption can be demonstrated easily by the simple expedient of not lighting the street lamps for a time, and taking note of the expressions of opinion regarding the insecurity felt by all citizens on account of the condition of total darkness.

The fact would be quickly apparent that unconsciously every one regards street lights as a protection as well as a convenience.

The quality of protection increases in value as that of convenience decreases. From dark until midnight, the lights are most valuable as a convenience. During those hours there are many people in the streets, the number gradually decreasing as the night advances. The more people there are in the streets, the less is the need of protection, for there is mutual protection in their presence. As their number decreases, the value of the light changes from that of a convenience to that of a protection. That this fact is not more frequently brought to notice, is an evidence that people do not see all the social or economic bearings of conditions to which they are accustomed, until their attention is directed to them by some discussion or failure of service.

An ostrich, when pursued, will hide his head and imagine himself out of danger. People will go to sleep when there are lights in the street, and have no thought of danger. If, however, by some emergency, they are obliged to be out during the hours from midnight until morning, they require no argument other than their experience with the silent fact of darkness, to convince them that lights on the street during those hours have a value as a protection alone, much in excess of their cost. So well is this value of protection understood in large cities, it is frequently urged as the only consideration for placing lights in certain positions, and for increasing their number.

If the subject is analyzed, it will be readily seen that the efficiency of a policeman is largely dependent upon his ability to see. Who would think of placing, no matter how acute his sense of hearing might be, a blind policeman on the street? It is equally ridiculous to employ a policeman to stay on the street, and then limit his power of observation to the lantern he may carry in his hand, or the diminutive light faintly flickering from a gas tip or an oil burner. This fact is so apparent that no argument is required to prove that it will take five times as many policemen to give the same amount of protection in unlighted streets as can be given by one-fifth their number in well lighted streets.

Light in the streets from midnight until morning insures peace and security. The social and economic value of these conditions is the value of light during these hours. These are the hours also, as has been shown, when the service can be obtained for the least cost. The question is not how much a city is willing to pay for light alone. It is a question of a more intelligent distribution of the amount IT IS PAYING *for light* *and protection.* The police department in such cities as Pittsburg, Baltimore, Philadelphia, Chicago, New York, and Boston, have given this question due consideration, and it is the feature of PROTECTION which is causing the general use of arc lights in those cities. Experience is teaching them that by having abundant light EVERY NIGHT AND ALL NIGHT, the policeman is more efficient; therefore, a less number is required, or, what amounts to the same thing, the same number can cover more miles of street. For this reason, the number employed is not increased with the increased growth of the city. Though many thousands of dollars are added to the street lighting account, the expense in the police department is held in check proportionately; as a net result, there is no increase of the total expense on account of the increased cost of street lighting.

In cities of the first class, the number of employes in the police department is about one per thousand of the population, and the cost of maintaining the department is about $1 per year per population. The cost of street lighting is about 60 cents per year per population. Ten arc lamps burned every night and all night cost about the same as one policeman. These statistics furnish a basis for calculating the value of the protective service of an arc lamp.

The effectiveness of a policeman can not exceed the area over which he can watch. It is therefore limited by the area lighted by the lamp with which he is assisted. One arc lamp will displace five ordinary gas lamps for street lighting; therefore, by its use, the area overlooked by a policeman is much greater than with gas lamps.

The additional expense for operating these lamps all night and every night, over the cost paid on the usual lighting schedule, is much more than compensated by the increased efficiency of the police force. As a result, the requirements of an enlightened and practical economy are satisfied only by operating these lamps for the full time during which mechanical light is needed, and by having the number sufficient to diffuse enough illumination to enable an observer to easily distinguish, in the darkest night, a moving object the size of a man, at a distance not greater than the area lighted by a single lamp.

All advantages considered, it is indisputably true that for street use, incomparably, the cheapest light in the world is the ARC LAMP.

THE GROWTH OF ELECTRIC LIGHTING.

The first electric central station using the incandescent lamp, constant current system, was put into operation September 4, 1882. The designers and builders of this station had only a theoretical knowledge of the requirements, electrical, mechanical, and commercial, of the business they were undertaking. They had no experience and no precedent to guide them, consequently the station and the electric system were experimental. Besides possessing defects in machinery, conductors, and other apparatus, the cost of the station and system were very much more than it could now be reproduced for on the improved modern basis.

Though hampered with all these draw-backs and disadvantages, this station *has run every hour since it was started*, and has from the start furnished a light which disinterested business men *use* in preference to gas. The full capacity of the station has been unable to supply the demand, and an annex station has been built.

Contrary to all predictions of opposing interests, *this station has earned and paid regular dividends from its first year.*

If the first electric central station has been able to make a record of this character, every year's experience must add to the permanency and profit of the business, not for this station only, but for all stations throughout the country.

A statement of the earnings and expenses reported from twenty electric central station companies, from June 1, to April 30, 1888, shows net earnings as follows:

Six companies	6% to 10%
Eight "	10% to 15%
Six "	15% to 20%

Two of the latter companies exceed 20%.

The circuits of some of these companies cover an area of *three square miles*. Over 90,000 lamps, using this system, are now supplying light to customers by meter measurement.

The direct outgrowth of this first central station, in nine years, is the establishment in the United States of about 190 central station companies, using the same system and having an aggregate capacity of about 500,000 incandescent lamps.

The first electric central station using the alternating current system was installed at Greensburg, Pennsylvania, about January, 1886. Since that time, there has been about 150 stations installed by one manufacturing company, having a capacity of about 300,000 incandescent lamps.

The first arc lamp manufacturing company was organized in 1879. This company's business represents about one-half of the arc lamps manufactured. They have sold about 3,000 dynamos. Their sales of all kinds amounting to date to over $10,000,000.

DIVIDEND EARNING CAPACITY OF COMPOSITE STATIONS.

No just estimate can be arrived at, of the economic value of the progress made by the electric industry, which does not take into consideration the meaning to investors in electric central stations, of the advantages gained.

Electric central stations were at first, necessarily, small and partial. The companies owning them were organized and stations were built, to use the apparatus made by one manufacturer.

Viewing the subject entirely in the interest of those who are or may become investors in electric central stations, it is clear that if manufacturing companies have done no more in these first years of their business than to so perfect their apparatus as to make investments in operating companies a reliable source of dividends, they have done enough to justify all investments, either in manufacturing or operating experiments.

The fact must always be kept in view that the electric industry had to commence without data for its guidance. It had to secure its business in competition with the gas lighting industry, having back of it, the capital and data accumulated during *fifty years* of service. It had the charges of danger to life, health, and property to meet; it had its employes and the public to educate in the manipulation and use of its apparatus and service, and it had to overcome the problem of cost of manufacture and operating expenses. If, under these conditions, a profit has been made by manufacturing or operating companies, that fact is proof that in no other industry can investments now be made with as great a certainty of their being permanent and profitable.

A comparison between the dividend earning capacity of the first central stations and the composite station that may now be installed will emphasize this fact. In the comparison, each notable improvement is estimated at its dividend earning value.

The first stations operated but one system, Arc or Incandescent. Their dividend earning capacity may be estimated at 6 to 10 per cent.

Taking this as the basis of calculation, the composite station of to-day may have a dividend earning capacity, as follows:

1. Arc system, original dividend earning capacity	10%
2. Incandescent system, original dividend earning capacity	6%
3. Increased power of distribution three wire system, or alternating current system, dividend earning capacity.*	4%

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* Incandescent System.

4. Meters for selling light by measurement, dividend earning capacity.*	3%
5. Motors for all mechanical uses, dividend earning capacity.†	30%
Prorating the dividend earning capacity of each factor on the total investment, the dividend earning capacity of a composite station having sufficient capacity to perform the entire electric service of a city is not less than	20%

Central stations originally supplied light only, and that by but one system. If the incandescent, they were restricted in their area of distribution, also in their service, for want of a meter. The fact that all such stations and those now being installed can be made exceedingly profitable by utilizing all dividend earning improvements, is no longer debatable.

To show how the dividend earning capacity of the incandescent service has been increased, it may be stated that the first stations could not distribute service over an area exceeding one-half of a square mile.

To-day a plant is being installed in Portland, Oregon, the generating power of which is located *twelve miles from the lamps.* The power of a water-fall will be brought to the city through conductors on a pole line running across the country. From the point where this line enters the city, branches will radiate through all streets. The company will start with 3,000 lights.

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* Incandescent system.

† Motors are made for both systems.

Improvements that have proven so many additions to dividend earning capacity, are not the only economic causes affecting the investment value of electric central stations. Many causes have combined to improve the quality and reduce the cost of all apparatus and accessories. The prices now paid, compared with the prices for the same supplies in 1883, show the following percentage of decrease:

Dynamos,	Increased efficiency	25%
	Decreased cost	40%
Incandescent lamps,	Increased efficiency	100%
	Increased life	100%
	Decreased cost	66%
Carbons	Decreased cost	75%
Wire	" "	20%
Line construction	" "	20%
Miscellaneous repairs.	" "	25%
Engines	" "	20%
Boilers	" "	15%
Oil	" "	30%

This list is sufficient to illustrate the fact. A complete list would not materially change the showing.

In the light of what has been said, a very pertinent question may be asked: "Is it wise to invest in electric central stations *now?*" I answer, most decidedly, "yes," and for the following reasons:

1. None of the improvements have rendered any of the original apparatus less efficient; they have all tended to render it *more efficient*. Therefore, it has not been, nor is there any probability that there will be, any loss occasioned by apparatus being superseded before it is worn out.

2. The whole tendency is toward large composite stations. The evidence of this is found as clearly in the efforts of manufacturers to extend their business to include all the requirements of composite stations, as in the tendency of operating companies to add apparatus to their plants, to enable them to perform service, which they have not been able to touch in the past.

3. Those who are in the business can earn dividends by using the apparatus now made, and will be in a position to be benefited by each subsequent improvement, as it becomes a commercial success.

SAFETY OF ELECTRIC SERVICE.

To speak of the danger of the electric service, is a misnomer. Those interested in having the idea of danger associated in the public mind with the uses of electricity, have lost no opportunity to teach their fraudulent lesson.

The economic value of electric light and power can not be fully understood until its effects upon health, life, and property are fully known and appreciated. In physics, safety is a positive condition, danger is its negative; just as in ethics, right is positive, and wrong is negative. As we have not arrived to a condition of absolute perfection, we must estimate all things by their comparative value. Greatest safety is least danger; therefore, that service is safest which does the least harm in comparison with the work done and the points of contact it establishes with the persons or property it may injure. Mind is impressed with no fact, as it is with the unknown. For this reason, so long as the manipulation and uses of the electric service are not matters of general information, the mystery surrounding it will predispose the uninformed to consider it dangerous. A great gain will be made when it is understood by intelligent people that, to speak of the danger of the electric service, is to advertise one's self as being uninformed.

WHERE DANGER IS FOUND.

The dangers from the use of coal oil are overlooked by reason of their familiarity. The reports of casualties from the use of coal oil, in the Cincinnati papers during the very brief period of eighteen months last past, make a record of

"FOUR THOUSAND FOUR HUNDRED AND FORTY-FIVE HOUSES BURNED;

FIVE MILLION DOLLARS' WORTH OF PROPERTY DESTROYED; and

THREE THOUSAND NINE HUNDRED AND THIRTY-FIVE LIVES SACRIFICED."

THE RECORDS OF THE CINCINNATI FIRE DEPARTMENT

Show that, of the original and known causes of fires during the past year, over ten per cent were occasioned by the explosion and ignition of coil-oil lamps and gasoline stoves; that the cost of maintaining the department was $282,769.51, and the losses by fire $1,272,875.83, or a total of $1,555,645.34—showing that the citizens of that city are called upon, either directly or indirectly, to contribute over *one hundred and fifty thousand dollars* every year toward defraying the losses and expenses incident to the use of coal oil.

THE LAST REPORT OF THE NEW YORK FIRE DEPARTMENT

Shows that nearly *one-fourth* of all the fires which occurred in that city during the past year were attributable to the use of coal oil.

Out of a total of 2,929 fires

302 were caused by the explosion of oil lamps;
177 by the upsetting and breaking of oil lamps;
183 by lamps setting fire to combustibles;
107 by the explosion of gasoline stoves;
89 by the ignition of benzine, naphtha, etc.

A total of 858 in one year, and a loss of $493,719.50.

THE OFFICIAL REPORT OF THE FIRE PATROL OF PHILADELPHIA

Shows that, during the past year, out of 844 known causes of fire, 92 were due to the explosion of coal-oil lamps, and 63 to the explosion of gasoline stoves and ignition of oils—making a total of 155, or nearly one in five.

Data of the above character can be furnished almost without limit, not only from our own country, but from every country in the world. What a striking contrast to this indictment against the use of coal oil, is furnished by the evidence of the insurance experts given before the National Electric Light Association.

ELECTRIC LIGHT STATIONS AS FIRE RISKS.

By S. E. Barton, Chairman Electric Light Committee, New England Insurance Exchange.*

. . . I can not refrain, in the outset, from congratulating myself, and my insurance associates in New England, upon the very cordial relations existing between ourselves and the electric lighting interests, and also upon the very favorable experience the Underwriters of New England have met with in having comparatively little loss to pay on account of the electric lighting fire hazard. Nor can I refrain from saying that, as favorable as our experience has been in the past, it is being, and will continue to be, made much more favorable through the good work undertaken, and being carried on through the New England Electric Exchange. Its influence and results tend in the right direction—to the education of those employed in electric lighting pursuits as to what practices and work are safe and what are not, and to the exclusion from such pursuits of any who may, through lack of proper scientific knowledge, be unqualified for the positions they hold.

As a matter of fact, however, I believe that the experience has been, that because men have been required to provide themselves with a license certificate as to their qualification, they have speedily and earnestly set themselves to work to gaining the necessary technical knowledge to qualify them to receive the certificate. It goes without saying, I think, that those men are thereafter more capable in their business, and safer men for all parties concerned, than they were before.

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* Extracts from Paper read before the National Electric Light Association, Chicago, February 20, 1889.

At the risk of giving voice to trite expressions, I am going to reassert that I believe we are all agreed that there is no element or force with which we deal that is more capable of self control than the one which called into existence this association, nor is there one prolific of danger or hazard in more ways when unscientifically and carelessly handled.

Now, then, having on the one hand an element so fraught with hazard, and on the other one so easy of control, your duty is obviously to do all you can by your own work to promote and secure safety, and to encourage all feasible plans and efforts of others tending in the same direction. While the plain duty of Underwriters in the public interest is, first, to hold to a strict line of requirements any of you who may be tempted or compelled, through competitive pressure, to depart from what you know are safe practices; and, having done that, the Underwriters' duty is not fulfilled until they have indorsed electrical illumination and power by the reduced premium charges that such combined action on the part of electrical and insurance interests is sure to warrant.

The two interests are peculiarly identical. Hand in hand they can accomplish much in reducing the enormous fire waste. Disunited and antagonistic to each other, your work will be slower in development. Competition among yourselves, and no restraining supervision on our part, will drive you to cheaper construction and maintenance of your work. More fire loss and higher premiums for insurance must inevitably be the result, while the public, still calling for your light because it is good, will be deterred to an injurious degree by reason of the increased insurance rates that will surely follow, such as have already been applied in some cases, and threatened in others. . . .

In New England, electric lighting is very popular with insurance men, particularly since it has, as applied to some risks, been included in the schedule of "improvements" for which a reduction in tariff is made. The energetic agent, in his efforts to scoop in his competitors' pet risks, does not fail to recommend the introduction of electric lights as a means of procuring a lower rate and securing the risk to himself. He thereby becomes your solicitor. He goes still further. In many cases he manifests his favor to you, and serves his own interests by becoming an investor in your apparatus, and a promoter of your industry. Such a condition of things is but the natural outgrowth of a perfect harmony and co-operation between the two great interests. It ought to exist throughout the land.

I would like to state still further that it not only touches your pocket, but I am free to suggest it touches my heart to see what I believe to be one of the safest classes of risks that we can have at the present time, through no reasonable excuse whatever, in such a condition that insurance companies will not touch them as a general rule. I believe that in our business generally about twenty-five per cent of the loss may be charged to what is known with us as moral hazard. I hold that this twenty-five per cent should be eliminated from the electric lighting hazard; there is no such thing as moral hazard in the Electric Light business. . . .

REMARKS BY CAPT. W. BROPHY, NEW ENGLAND INSURANCE INSPECTOR OF ELECTRIC WIRING.

The insurance people of New England, perhaps, have taken a more intelligent view of the electric light matter than most any other body of insurance men throughout the United States. . . . It is now too late for me to say that every one recognizes that the electric light is the best form of artificial illumination known at the present day. It is for you gentlemen to prove to the masses of people of this country that it is also the safest. That you can do, I am sure. I find that now the various companies—construction companies and electric light companies—heartily co-operate with the insurance inspector in attempting to prove this. When we have competent men in every station in New England ready and willing and taking a pride in doing their work as they ought to do it, the sensational newspaper of the day will have one less theme to expatiate on. . . . In New England we have had scarcely any loss to speak of, when the amount of property invested in electric light stations is taken into consideration. . . . The moral hazard that is attached to a great many other kinds of business fortunately does not exist in this. You are under the contract to deliver a certain article; you must deliver it every day in the year; there is no motive whatever for the electric light companies to saddle off their property on the insurance people; and when the insurance people understand this thoroughly, and many other things that we ought to know, I think there will be no friction—certainly not in our section of the country, and we hope to educate those in other sections up to our standard. . . . All now that is required of you gentlemen is to do what you know how to do, and see that it is done—to make fires caused by electric lights or electric light wires so scarce that they will hardly ever be heard of. . . . The fires in New England, unfrequent as they have been, have not been confined to any one particular system of electric lighting; they are equally distributed among different kinds, or among different systems; but happily they have been so few that very little or few losses have had to be paid. We have had, since the introduction of electric lighting in New England, four electric light stations burned—two of them from causes entirely separated from the business carried on in them. Two might possibly have been traced to electrical causes, and each one might have been prevented by a reasonable amount of forethought. When you take into consideration the amount of money invested in New England—over ten million dollars, I think—in electric light stations, that is but a very small amount.

Remarks by D. Killicut, Boston Insurance Inspector of Electric Wiring.

. . . We have only had in Boston, since I have been there (five years), about fifty fires, and the whole loss of these fifty fires is only in all something about $34,000, and these ranged all the way from, perhaps, $2.50 up. There were a great many fires, as Mr. Brophy says, in reporting which the intelligent newspapers gave the public a large headline, which frightened the people nearly to death, and kept the public in a state of fright which some of the companies in Boston would like to make capital out of, taking advantage of one another's misfortune. They stirred up the insurance people, who are not supposed to know a great deal about electric lighting; they are better insurance brokers than electricians, and, of course, there is a great deal of disturbance; but I think the matter has quieted down now, and I trust that a few years hence, as Mr. Brophy says, I shall probably be looking for another position. We are willing to sacrifice our positions for the benefit of the public.

ELECTRIC LIGHT AND HEALTH.

In his address before the Cincinnati Electrical Society, Dr. Otto A. Moses said:*

"In this hall the air is fresh and sweet, which condition is largely due to the absence of gas. We are accustomed, when we feel an evil to which we have been habituated, to lose sight of its being an evil, and we do not often recur to the fact; we try to take it as one of those unavoidable things—just as when we are fatigued, it is our poor human nature. We have admitted into our households in gas one of the most poisonous agencies that I can well think of. It is there to be turned on at an instant by careless children and servants. We are being poisoned by it all the time. Let one of you try to make a perfectly tight joint, and you will find that it becomes a high art. You can not prevent the leakage of gas. It will take place imperceptibly. We feel overcome by a lassitude, and we do not know why—malaria! Nine times out of ten it is gas. There is in gas of all kinds, the most improved forms of gas, carbonic oxide, which is highly poisonous, and if taken into our systems, the effects will gradually undermine our constitutions. That is one of the indirect disadvantages of gas. The supplanting of that by electric light will be of great advantage.

The *Rochester Morning Herald* says:

"Gas is valuable for illuminating purposes, and will remain in use for an indefinite period of time, no doubt; but when the incandescent electric light can be secured on nearly equal terms, it is in several respects incomparably superior to gas or any other illuminating agent. The advantage of the incandescent lamp over gas is especially apparent in that the former does not vitiate the air of an apartment. The carbonized filament that is raised to incandescence and furnishes the light is inclosed in an air-tight glass bulb, and, therefore, though a hundred of them be burning in a closed room, no oxygen is taken from the apartment, and the air of the room remains as pure as if no lamps were burning. It is estimated, we believe, that a single gas jet, speaking generally, consumes more oxygen than a human being. The difference in the purity of the atmosphere of a room, the windows and doors of which are kept closed as in cold weather, is therefore almost immeasurably in favor of the incandescent light. Where there are several occupants of such a room, as in the various apartments of public buildings, their health, as well as the cost of the several systems of lighting respectively, should be considered."

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* Mechanics' Institute hall, October 9, 1888. Reported in the Western Electrician, October 20, 1888.

The English journal, *Health*, says: *

"Electric lighting, as a means of preserving and promoting health, has not been sufficiently appreciated by the British public. It may be safely said that electric light is the only form of artificial illumination which is not injurious to health. This is a strong argument in favor of the general introduction of the electric light; but it is when we begin to compare this light with that of gas, or any other artificial lights, that its beauty purity, brightness, cleanliness, and safety come out in strongest contrast.

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* The Electrical World, February 16, 1889.

"Gas not only consumes and pollutes the air, but it is very poisonous, besides having a deleterious effect on the furniture and decorations of our homes. Gas gives off a certain amount of soot, which is evident from the blackened ceilings and cornices, discolored paper, etc. The destruction to goods in the shops of our great cities from the action of gas must also be very great. In offices, shops, and factories, employes can use it continuously without feeling the lassitude, headache, and fatigue which are frequently caused by the use of gas. As a means of retaining health, the advantages of the electric light are indisputable.

"The electric light is a pure, healthy light, which, if no other were used, and the smoke of our fires self-consuming, would leave our cities almost as fresh and bracing as a highland hill, and rosy instead of pale cheeks, and brightly-flashing instead of dim, lusterless eyes would mark the city inhabitants."

PERTINENT ITEMS.

1. "When the Birmingham, England, public library was recently cleaned and renovated, some hundreds of books had to be sent to the binders to be rebound in consequence of the injury done by the waste products of the gas consumed in the library.

2. "Oil gives off about three times its weight of carbonic acid, and gas about twice its weight; the remainder of the oxygen coming off as harmless water vapor."

DEATH IN THE WIRES.

The public mind has been awed by the sensational reporter, who has never missed an opportunity to write on the fruitful topic of the "deadly wires." The politician has added his work to that of the reporter, anxious to win cheap notoriety by authorizing legal executions by electricity. Seizing the opportunity thus afforded, one person, to gain a reputation as an electrical expert, has used every conceivable means to fix upon a certain system a stigma because it was selected for criminal executions. Thus sensation, political chicanery and selfishness have combined to blacken and disgrace the most beneficent servant Science has ever subdued to the uses of man.

To show how absolutely without foundation the representations made by these instructors of the public are, I ask careful attention to the following:

1. I was present at a meeting of The Electric Club, of New York City,* when *Dr. J. M. Bleyer*, of the Medico-Legal Committee of New York, appointed to devise a method for executing criminals by electricity, gave a description of the apparatus to be used. In speaking of the currents, he said:

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* Regular meeting, held November 15, 1888.

ELECTRIC LIGHT versus KEROSENE.*

It has heretofore been supposed that the one rival of the electric light is gas; but we are now furnished an example in which the cheapest kerosene has actually been profitably replaced by the electric light. It has long been suggested that electric lights are eminently adapted for railroad signal purposes, but the idea seems to be slow in gaining possession of the minds of railroad superintendents. It is gratifying to note, however, that Mr. W. W. Slater, master of signals of the Southern Pacific Railroad, at Oakland, Cal., has inaugurated a practice which, we believe, must soon be followed in a great many instances. In the *Railroad Gazette*, Mr. Slater describes the manner in which the signals in the yards have been fitted up with incandescent lamps, for which purpose he employs normal sixteen c. p. lamps, run up to twelve candles. This light of twelve candles, passing through the corrugated lens of the lantern, gives a bright, clear, steady beam, strong enough for all practical purposes. The reduced candle power at which the lamp is run insures a long life for the lamp. The result is shown by the fact that these lamps, without any difficulty of attention other than occasionally cleaning the glass lens on the outside of the lantern, have been burning over 2,600 hours up to date, or a portion of every night for one year and sixteen days; and, according to Mr. Slater, they are probably good for another year. All this lighting, in addition, is done without a current governor, or regulator on the circuit—the current being furnished from arc machines, and the lamps placed in multiple series. It is interesting to note that, as above stated, the electric lighting has proved cheaper than kerosense; for Mr. Slater shows that the average cost of one oil lamp for one month is sixty-five cents, for oil and labor in cleaning, filling and lighting, and about twenty-five cents for depreciation of lamps and lamp burners; whereas the average cost of the electric light, with one lamp, for one month, is thirty cents. For the loss by depreciation of lamps and machines, oil, waste, etc., there are no data on which to base an estimate; but, according to Mr. Slater, the amount is inconsiderable, when taken in connection with the other lights employed at the station. With proper machinery, regulation, etc., it seems probable that the cost of coal could be reduced one-half. Again, the original cost of wire and material for an electric light plant compares favorably with the cost of expensive oil lamps. All these advantages must be taken, too, in connection with the fact that engineers express themselves as much pleased with the electric lights and signals; that the signals are always lit, and the light is always brilliant; that there is no dirt or smoke; while, on the other hand, the oil lamps are hard to keep burning; invariably drafts of air cover the lamps with smoke and carbon and the signals with oil and dirt; and not infrequently go out, and have to be relit. It is not difficult to discern that electric light signal lanterns will be employed in many railroad yards as soon as their value is recognized, which now seems to be the case.

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* Reported in The Electrical World.

that we had more accidents with steam engines; that even the building of houses in the city caused more deaths every year—infinitely more deaths in this city—than this particular agency. I was therefore driven to the conclusion that, considering the work it was doing—comparing it, if you like, with the illumination by gas—that it was positively safer, just as the railway had proved to be safer than the stage-coach, and the stage-coach probably safer than walking for the number of people carried. I found that, with all the difficulties with this thing, the absolute results seemed to show that it was absolutely safer than any other useful agency at work in this city. I may be wrong, but that was the conclusion to which I was forced. But then when I investigated the cause of the accidents, I discovered that they were not due to any thing that was inherent in the transmission of the current overhead; but it was rather due to two causes: either the carelessness of the company in inspecting its installation and keeping it in good order, or in the carelessness of the person who came in contact with it—one or the other.

"Now, there is no excuse for the company, not the slightest. They undertake to render a public service; they are paid for it; they undoubtedly ought to see that their plant is in the most perfect order possible; and any company that neglects to keep its plant in proper order is, of course, liable to the penalties of the law, and I would be the first to have the officers of such a company indicted, if I could. But I take it that the duty has been, on the whole, pretty well performed, because the accidents have been so few. They have been very few, indeed. I believe that in this city there

THE ELECTRIC INDUSTRY IN THE UNITED STATES.*

S. A. DUNCAN, PRESIDENT NATIONAL ELECTRICAL LIGHT ASSOCIATION.

. . . It may be remembered that in the early days of this association the chief question before the electrical fraternity was the then all-important question of Arc lighting. The Incandescent light had scarcely come into commercial use. No sooner had the questions involved in arc lighting been solved by the natural pressure of public demand than the complicated questions involved in the distribution of incandescent lighting absorbed the attention of the fraternity, and occupied the meetings of this association. Following closely upon the problems involved in incandescent lighting came the question of electrical distribution of power, first for stationary motor purposes, and afterward for the purpose of electrical locomotion. This question is to-day, perhaps, the most important one before the electrical fraternity. To say that electrical power is not to-day a success would be to reflect upon the scores of electrical railways now in successful operation in this country, and upon the thousands of electrical motors that are every day commercially serving the wants of man.

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* Extracts from address delivered at the Ninth Semi-Annual Convention of the National Electric Light Association, Chicago, February 19, 1889.

We may here profitably consider some figures indicating the growth of the electric lighting and power industry, the increase in the number of central stations, arc and incandescent lamps, electric motors and electric railways now in operation. At the meeting of this association one year ago, it was estimated that there were not less than 4,000 central station and isolated plants in operation in the United States.

The number of central stations and isolated plants at the present time is 5,747, a total increase during the year of 2,067 plants. The percentage of increase during the year is 45.8 per cent.

It was estimated a year ago that there were 175,000 arc lamps in daily use in the United States. At the present time, I find that there are 219,924, making an increase of arc lamps in use during the year of 62,625. The percentage of increase during the year is 34.3 per cent.

A year ago it was estimated that there were 1,750,000 incandescent lamps in use in the United States. At the present time there are no less than 2,504,490, making a gain for the year of 754,990 incandescent lamps. The percentage of increase during the year is 49 per cent.

It is also interesting to notice what the increase in capitalization has been in electric light companies of the United States during the year. During the first half of the year the increase was $42,210,100; during the latter half it was $27,187,634, making a total gain during the year of $69,397,734.

There are 53 electric railroads in operation in the United States. The number of roads now under construction not finished is 44. There are 42 electric railroad companies incorporated that have not yet begun the work of construction. There are 379 electric cars in operation, and 339 under contract. There are 294½ miles of single track in operation and 273¾ miles under contract.

It would be profitless for me to draw elaborate deductions from these figures; they tell for themselves the story of prosperity and rapid growth throughout every department of the electric light and power industry.

ELECTRICITY IN ENGLAND.

FROM AN ADDRESS BY W. H. PREECE, F. R. S., PRESIDENT OF THE BRITISH ASSOCIATION.*

Electric lighting has become popular, not alone from the beauty of the light itself, but from its great hygienic qualities in maintaining the purity and coolness of the air we breathe. The electric light need not be more brilliant than gas, but it must be more healthy. It need not be cooler than a wax candle, but it must be brighter, steadier, and more pleasant to the eye. In fact, it can be rendered the most perfect artificial illuminant at our disposal, for it can illumine a room without being seen directly by the eye; it can be made absolutely steady and uniform without irritating the retina; it does not poison the air by carbonic acid and carbonic oxide, or dirty the decorations by depositing unconsumed carbon; it does not destroy books or articles of virtu and art by forming water which absorbs sulphur acids; and it does not unnecessarily heat the room. In our Central Savings Bank in London, it has been found, after two years' experience of electric lighting, that the average amount of absences from illness has been diminished by about two days a year for each person on the staff. This is equivalent to a gain to the service of the time of about eight clerks in that department alone. Taking the cost at the "overtime" rate only, this would mean a saving in salaries of about $3,200 a year. The cost of the installation of the electric light was $16,745, and the annual cost of working, $3,500 per annum—say a total annual cost of $5,170. The cost of the gas consumed for lighting purposes was about $3,500 a year, so that on the whole there was a direct saving of something like $1,330 a year to the government, besides the material advantage of the better work of the staff resulting from the improved atmospheric conditions under which their work is done. The production of light by any means implies the consumption of energy, and this can be measured in "watts," or the rate at which this energy is consumed. A watt is $\frac{1}{746}$ part of a horse-power. It is a very convenient and sensible unit of power, and will in time replace the meaningless horse-power.

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* Before the Bath meeting, 1888. Reported in "Electrical Review."

One candle light maintained by—		Watts
Tallow	absorbs	121
Wax	"	91
Sperm	"	86
Mineral oil	"	80
Vegetable oil	"	57
Coal gas	"	68
Cannel gas	"	48
Electricity (glow)	"	3
Electricity (arc)	"	0.55

The relative heat generation of these illuminants may be estimated from these figures. Though the electric light was discovered by Davy in 1810, it was not until 1844 that it was introduced into our scientific laboratories by Foucault; it was not until 1878 that Jablochkoff and Brush showed how to light up our streets effectually and practically; it was not until 1881 that Edison and Swan showed how our homes could be illuminated softly and perfectly. Unpreparedness for such a revolution produced a perfect panic among gas proprietors; inexperience in the use of powerful electric currents resulted in frequent failure and danger; speculation in financial bubbles transferred much gold from the pockets of the weak to the coffers of the unscrupulous; hasty legislation in 1882 restricted the operations of the cautious and the wise; and the prejudice arising from all these causes has, perhaps fortunately, delayed the general introduction of electricity; but now legislation has been improved, experience has been gained, confidence is being restored, and in this beautiful town of Bath 50 streets are about to be lighted, and we see every-where around and about us in our English homes the pure glow lamp, replacing filthy gas and stinking oil. The economical distribution of the electric current over large area is annually receiving a fresh impetus. The expensive systems defined in the Act of Parliament of 1882, have entirely disappeard. Hopkinson in England and Edison in America showed how a third wire reduced the weight of copper needed by 66 per cent. Gaulard and Gibbs, in 1882, showed how the conversion of alternate currents of high E. M. F. to currents of low E. M. F. by simple induction coils would enable a mere telegraph wire to convey sufficient electricity to light a distant neighborhood economically and efficiently. Lane Fox, in 1879, showed how the same thing could be done by secondary batteries; and Planté, Faure, Sellon, and Parker have done much to prove how batteries can be made to solve the problem of storage; while King and Edmunds have shown how the distribution by secondary batteries can be done as economically as by secondary generators. The Grosvenor Gallery Company in London have proved the practicability of the secondary generator principle by nightly supplying 24,000 glow lamps scattered over a very wide area of London. The glow lamp of Edison, which in 1881 required 5 watts per candle, has been so far improved that it now consumes but 2½ watts per candle. The dynamo which, in the same year, weighed 50,000 pounds, absorbed 150 horse-power, and cost $20,000 for 1,000 lamps, now weighs 14,000 pounds, absorbs 110 horse-power, and costs $2,500 for the same production of external energy; in other words, its commercial output has been increased nearly six times, while its prime cost has been diminished eight times. The actual cost of the production of one candle light per annum of 1,000 hours is as follows:

Sperm candles	$2.12
Gas (London)	.31
Oil (petroleum)	.16
Electricity, glow	.18
Electricity, arc	.03

The greatest development of the electric light has taken place on board ship. Our Admiralty have been foremost in this work. All our war ships are gradually receiving their equipment. Our ocean-going passenger ships are also now so illumined, and perhaps it is here that the comfort, security, and true blessedness of the electric light is experienced. Railway trains are also being rapidly fitted up. The express trains to Brighton have, for a long time, been so lighted, and now several northern railways, notably the Midland, are following suit. Our rocky coasts and prominent landfalls are also having their light-houses fitted with brilliant arc lamps, the last being St. Katherine's Point on the Isle of Wight, where 60,000 candles throw their bright beams over the English Channel, causing many an anxious mariner to proceed on his way rejoicing.

We learn from the instructive and interesting advertising columns of our newspapers that "electricity is life," and we may, perhaps, read in the more historical portion of the same paper that, by a recent decision of the New York Parliament, "electricity is death." It is proposed to replace hanging by the more painless and sudden application of a powerful electrical charge; but those who have assisted at this hasty legislation would have done well to have assured themselves of the practical efficacy of the proposed process. I have seen the difficulty of killing even a rabbit with the most powerful induction coil ever made, and I know those who escaped and recovered from the stroke of a lightning discharge.

ELECTRICITY IN LONDON.

FROM AN ADDRESS BY SIR JOHN PENDER, K.C.M.G., CHAIRMAN OF THE METROPOLITAN ELECTRIC SUPPLY COMPANY.*

. . . The station at Whitehall avenue, which has about 10,000-light capacity, was opened on the 15th of October, 1888, and the directors had hoped that the full capacity of lighting would be taken up by customers in seven or eight months. Instead of this, the full capacity of the station is already taken; in about two months, orders were booked for nearly 9,000 lamps. . . The Avenue Theater, the Hotel Victoria in Northumberland avenue, and other places, have been lighted for some time, and the managers have written expressing their satisfaction with the supply; and among the more recent contracts secured, to be worked from the Whitehall Station, are the Grand Hotel, Messrs. Hampton's large furniture warehouses in Pall Mall, St. Martin's Church, and other places.

The company's mains are being laid underground throughout the whole of the Charing-Cross district, and have already been laid across Northumberland avenue, West Strand and Trafalgar Square, without causing any appreciable interruption to the traffic. The guaranteed revenue from the contracts made and to be carried on from the Whitehall works is $67,500 a year; and the other contracts, expected to be completed in a few days, will be another $5,000, making altogether $72,500. The working expenses, including rent, salaries, wages, and ten per cent for depreciation, are estimated at $30,000, leaving a profit of $42,500 per year—on these installations—which, I think, is fairly satisfactory, seeing that the capital represented by these works is not much over $200,000. . . .

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* At an extraordinary general meeting of the shareholders, December 4, 1888. Reported in "Electrical Engineer."

The Sardinia Street Station will be one of the most important in London. . . . . That station will, I think, have altogether 50,000 lights. . . . If the results upon the 50,000 lights are at all in proportion to what we now see from the practical working of the Whitehall works, I think we may congratulate ourselves on being in a position to make very handsome dividends. I may mention that the machinery for this station has been ordered from an American company, and the bulk of it will be delivered in a very short time. . . The principle we have gone upon has been to take the very best in existence and to utilize it for our purpose. . . I do not mean to say that in electricity, as in other things, there is not very great progress. You will see that that is the case when I tell you that it is scarcely ten years ago since electric lighting was a laboratory experiment, whereas it is now almost becoming universal. I may go further and say this: It is not more than twenty-five years since submarine telegraphy was first introduced, and there are now $200,000,000 in the bottom of the sea, the major portion of it paying a fair dividend. . . .

The population of this mighty city is 5,000,000 of people; and if electric lighting is successful, and I believe it must become the light of the future, we shall require to spend $170,000,000 to $175,000,000 before we can do the work required. . . . Electricity is yet in its infancy; and the more that science can be brought to bear upon it, the more we shall have of this light. The light is doing a great sanitary work; and with its use the air remains pure, and there is less heat. I have not a word to say against gas. I believe that gas, being the essence of heat from coal, has a great deal of work before it, but in another field than that of lighting. Those interested in gas must look to apply it to other purposes. The light of the future is the electric light.

Theater Lighting.—There are ten theaters and music halls, not reckoning Olympia, illuminated by electricity in London. There are thirteen theaters in Paris possessing installations of the electric light, and eleven more in other parts of France; two in Spain; one in Belgium; thirteen in Germany; several in Denmark, Sweden, Norway, and Austro-Hungary, Italy and Russia, and one in Finland.

LONDON GAS.

The papers on the development of the electric industry in England and London will be better appreciated, if the price of the gas, with which the electric light has to compete, is kept in mind.

I take the following from *Modern Light and Heat:*

"The average price in London last year was 66 cents per 1,000 feet. The provincial companies charge an average rate of 56 cents per 1,000 feet. In 1869, the price of gas in London ranged from 79 cents to $1.12 per 1,000 feet. Since 1869 the capital employed by London gas companies has risen from $39,144,220 to $70,840,995. In the same period, the net profit has risen from $3,384,785 to $7,001,565. The gas sold in 1869 aveaged 8,438 feet per ton of coal, whereas now a higher lighting power is obtained, at the rate of 9,618 feet per ton. The coal in 1869 cost a little under 50 cents for each 1,000 feet of gas sold, whereas last year the price per 1,000 feet was only 30 cents. Still more striking is the difference, if we allow for the residuals. Deducting the revenue from this source, the coal in 1869 cost 29 cents per 1,000 feet of gas sold, whereas last year the net price of the coal was but little more than 12 cents. The consumption of coal, requisite to keep up the London gas supply, is now very nearly 7,000 tons per day, upon the average. The customers of the companies, reckoned as consumers, are nearly 300,000, or nearly 104 to each mile of main. The public lamps are about 70,000.

THE UNION OF ELECTRICITY AND GAS.

The economic value of electric light and power has received no testimony more marked than that accorded by the changed attitude of those who are identified with the gas industry, from opposition to adoption. This change, however, is not more marked than the change of attitude toward the gas industry by those identified with the electric service.

At the outset, the enthusiasm born of young blood, the prestige of new and wonderful discoveries or inventions, and complete ignorance of the difficulties in their way, caused electricians to proclaim that the day of usefulness for gas was drawing to a close—that it would soon become "a relic of the past."

So plausible did this at first appear, in *the new light* of new inventions of the highest value, that there was a momentary flutter in the price of gas stocks, a little unsettling of values, and then a settling into the normal condition again. Why? Not because the crucial tests of applying electricity to practical work developed any flaw in its nature-right to occupy the "promised land," but because the child of promise was not born fifty years old. It required time for maturity. It was not ready to occupy the field. Some, interested in gas investments, forgetful of the trials of their industry in its youth, fell into the error of comparing the achievements of electricity at one and two years of age with gas at fifty. Arguing from this mistaken premise, they convinced themselves and attempted to convince the public that there was nothing in electricity but danger, disappointment and financial disaster.

The lusty growth of the new-born industry, in five years, has challenged the attention of the civilized world. This has caused those identified with the gas interest to properly study its achievements and promises of future results by comparing them with that of gas, age for age. As a result, they are becoming prominent in the new development.

Darwin has said: "Ignorance more frequently begets confidence than knowledge; it is those who know little and not those who know much, who so positively assert that this or that problem will never be solved by science."

In this case honors are easy. The electric men asserted that electricity would put out the gas. The gas men asserted that it would not. Both possessed the confidence of ignorance. Men of science—the men possessing real power, because they work with the strength of truth—the men of achievements, have proven both right, but in a way little expected by either.

These men of science have so nearly solved the problems of the generation, distribution, subdivision and practical application, on a commercial basis, of electricity to the uses of light and power, that there can no longer be a doubt as to the final result.

These men of science have sustained the economic value of gas, by demonstrating its superior usefulness for heating to that of lighting, thus opening a new field for it many times greater than the one it has been occupying.

An adversary is overcome only when he becomes a friend. Science first shows how welding may be done, then the men of practical application use the forces as taught, and welding is done.

Electricity and gas may be generated from the same source—coal—heat. To be made helpful servants for the uses of light, heat and power, they must be sent on their mission of service through the same streets; why not from the same central station? Why not conform to the requirements of economic law in all conditions surrounding their generation, control and administration?

The profitable run for lighting service does not exceed four hours a day. Think of the enormous ability to decrease prices and increase profits that would be acquired if, by some inconceivable change in the sun, we were deprived of light, only, so that the profitable run for lighting service could be extended from four to ten hours per day.

A better thing than this can be done. Composite stations can be installed to supply the entire electric and gas service of a city. Their output then would be:

1. Electricity for power,	profitable run,	10	hours	per day.
2. Electricity for light,	“	4	“	“
3. Gas for light	“	4	“	“
4. Gas for heat,	“	10	“	“

The actual hours of service, however, would so overlap each other, that there would not be one hour in the twenty-four when the station could not be operated at as good a profit as that of the most profitable hours for any single service operated in isolation.

Light has been the thing thought about and contended for in the interest of electricity and gas. Let them be united in light, and, by conforming to true economic conditions, secure to the uses of man the service of light, heat and power, on a basis of cost and applicability which will be a benefaction to the race.

The genius of generalship consists in knowing when the decisive blow shall be struck. The genius of industrial management consists in knowing when to discard the old and adopt the new, when to eliminate antagonism of interests by uniting them. The time has come for the union of electricity and gas. Those will profit by it most who see it clearest and act the quickest. The uniting process has already begun. It will go on to completion. It is ordained by the nature of the two industries. No man can long delay the coming of the inevitable. Where the gas interest does not unite electricity with its service, the electric interest will become strongest and absorb the gas interest.

Some gas men may ask, "Why should we take any notice of electricity except to applaud it? for wherever it is brought into use, it has proven an educator in the use of light and has caused an increase in the consumption of gas." That is true. Then accept it as an educator, and employ it where it can do its teaching to best advantage. Adopt that form of it which yields most light for smallest outlay, the arc lamp, for street illumination. Do it thoroughly, and it will cause an increased consumption of gas of at least twenty-five per cent. For this alone it is valuable to you. But do not deceive yourselves with the idea that this phenomenon of increased consumption for lighting will long continue. The incandescent lamp is as sure to invade the field of commercial and residence lighting as the arc lamp has that of street lighting. Those who hug the delusive phantom that electricity will not supersede gas for illuminating service, will do so to their ultimate discomfiture.

The clearest minds in both interests, having changed their position because of a better understanding of the subject, lead the way and proclaim the union. What will be the result? Those companies that devote themselves with the greatest energy to supplying electricity for light and power through the area covered by their gas mains, and to supplying gas for light and heat, may succeed, in the course of four or five years, in doing all illumination by electricity; but it is doubtful. Gas has not superseded coal oil in fifty years. The change will be one of growth, not of transformation. But of one thing there is no possible doubt: they will increase their income and pay good dividends, while improving the service and decreasing its cost; and, most important of all to them, will keep their field of action free from competitors.

ELECTRICITY AND GAS.

OFFICE OF
THE CINCINNATI GAS LIGHT AND COKE CO.,
CINCINNATI, *March* 7, 1889.

MR. A. R. FOOTE:

Dear Sir—I approve cordially the position you have taken, and so well sustained, on the subject of "Municipal Ownership of Commercial Monopolies," in the paper read by you before the National Electric Light Association at its recent meeting in Chicago.

In my opinion, the Association has taken a wise and important step in appointing a "National Committee on State and Municipal Legislation." Such a committee ought to accomplish much needed and very beneficial results, if properly co-operated with and sustained.

I think the time has come when the electric and gas industries should be united to perform the service of supplying cities and towns with light, heat and power.

This company has had the subject under consideration for some time, and would have undertaken the electric service a year ago, but for a doubt in the minds of some of the directors as to our legal right to do so.

In its relations to the gas industry, the electric light now occupies a higher and broader relation than it has in the past. Rather than rivals, they should be companions in trade; and the closer this association becomes, the better and more profitable will it be for both producer and consumer.

The control of the electric industry has been secured by men of integrity, and the business has assumed the aspect of a legitimate undertaking. Gradually it is being freed, by the efforts of honest men, from the grasp of cormorants who fattened upon the credulity of their victims, duped and misled by the representations of interested promoters of wild speculative schemes; and is now generally regarded by thoughtful business men as an established and honorable enterprise, which, if wisely and economically managed, can be made reasonably profitable.

While I do not feel that the electric light is a serious competitor with gas, it has some special uses and advantages; and my idea is, that if the citizens of our city, for any reason, even an imaginary one, desire that character of light, it is but just to them that we should supply it in the best possible shape and at the lowest possible rates.

The generation and distribution of electricity is now followed for three separate and distinct purposes. The arc lamp undoubtedly supplies a degree of illumination which can not be given with gas. It is peculiarly adapted for street illumination and for all large areas.

The incandescent lamp is suited for interior illumination, and though generally inferior to gas in illuminating power, and more expensive, a certain portion of the citizens of every city will have it regardless of cost. The electric motor may be employed to drive any kind of machinery requiring limited power, and bids fair to become an important factor in the social and industrial economy of all large cities.

Organized gas companies are usually owned and controlled by wide-awake and enterprising citizens,interested in the introduction of any thing that will add to the comfort and convenience of their fellow-men. Can any more efficient and responsible agency be found for supplying the electric service of a city than these long-established, well-organized and efficiently managed companies—managed, as they are, by men favorably disposed toward fostering any industry which will bring to them a fair and reasonable manufacturer's profit on capital invested?

Thus controlled and governed, my own personal judgment is that cities will be much better, more economically and more satisfactorily served by one responsible company, operating under a strong municipal ordinance, carefully guarding all public and private interests, than they can possibly be under present circumstances.

In this State, the law permits applicants to appeal from the authority of municipalities to the less interested probate courts, and it only remains, to secure the best service attainable, for all companies to undertake it, and let the public indorse the survival of the fittest.

Gas companies having complete organizations in running order, can add to their plants the necessary of doubtful legality, but be entered upon in good faith under the authority of a general law which will clear away any doubts as to the legal rights of existing companies to enter upon such an undertaking. As gas companies were formed for another, though a very similar purpose, it is necessary, in Ohio, that such a law be passed, to enable them to enter the electric business in proper and legitimate shape. Of course, we could go on and supply electricity just as over a dozen gas companies in this state have already done, and take the chances of some crank raising the question; or we could form an outside corporation and conduct the business ostensibly as a separate one; but the directors of this Gas Company are a very conservative body of men, and prefer to hew straight up to the line and indulge in no false pretenses. Very respectfully,

A. HICKENLOOPER, *President,*
The Cincinnati Gas Light and Coke Co.

FROM INAUGURAL ADDRESS BY HON. F. BECK, PRESIDENT SOUTHWESTERN GAS ASSOCIATION.*

The next movement to share the revenues derived from furnishing artificial light and power by coal gas companies was made when, in 1879, the Electric Light and Power Company went into operation in Galveston, at first furnishing, principally, arc lights, but later a limited number of incandescent lights on arc light circuits. We, interested in the manufacture of coal gas, were eagerly watching the results of this new enterprise throughout the country, but more particularly those surrounding us; and doubts so easily harbored as to its success made us feel that coal gas must be victorious, and that it would maintain its superiority over all other contrivances brought in the field against us. When, years ago, water gas made its appearance as an illuminant, it seemed to be a criminal act to speak favorably of it; but to-day the largest coal gas companies manufacture it, either as an auxiliary to coal gas or furnish it as strictly water gas. The desire to compete, to furnish more and cheaper light, silenced the carbonic oxide opposition.

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* Meeting held at Galveston, Texas, August 20, 1888. Reported in American Gas Light Journal, September 17, 1888.

The immense efforts made to use carbon in every possible combination from illuminating to producer gas show very plainly that we desire the commercial success of the products of our manufacture. Against the dangers, we must guard, as the lineman who is around a circuit carrying from 2,000 to 3,000 volts electrical pressure. There is danger every-where; and to avoid accidents, our motto should be: "Handle with care."

I trust you will not construe my words in regard to dangerous appliances as meaning that I do not possess a proper brotherly feeling for my fellow-men. I must protest against any such construction. As long as there is no legislation prohibiting their introduction, we are compelled to satisfy the demands of our consumers and the public, or turn over our business to others. The efforts of scientific men to apply the laws of physics, by the aid of mechanical constructions, to furnish light and power, can not be treated with indifference. Electrical machinery will be more and more in demand For us the question is: "Shall it be in competing hands, or shall it be used as a branch of establishments that have made it their business for years to furnish light, heat and power?" We all are able to compete with electric light. There is no doubt that any gas company to-day, on an actual capital invested, can realize better profits than electric light companies, provided they both supply the same area and give service during twenty-four hours. But does this change our position? In my opinion, it does not. Gas and electric light are demanded by a public who gives preference to one or the other. Electric light has in its favor the novelty stipulated rates and prices, and the easy maintenance of installation where incandescent lamps are used. Who are really benefited by the progress in electric lighting? The dynamo builder, the manufacturers of the numerous electrical appliances, the copper-wire firms, the steam-engine builders and boiler makers, all find, comparatively speaking, an unlimited amount of business, which they will, without doubt, hold in the future.

We all represent small gas works, and a division of business between two lighting companies, even at fair rates, would not be sufficient to secure for either a commensurate compensation on the capital invested. What is more natural, then, that the applications for franchises to erect electrical plants in towns and cities should more or less alarm the managers of existing gas works—that they feel the necessity of exchanging notes with others engaged in the profession, so as to be able to select the most appropriate additions to their plants, to improve the works under their charge, and to gain a knowledge of all appliances used at present for furnishing, at low rates, light, heat and power; also, to select the best market for the purchase of raw material and machinery used.

FROM ANNUAL ADDRESS BY HON. THOMAS TURNER, PRESIDENT AMERICAN GAS LIGHT ASSOCIATION.*

The application and use of electric light has really had the effect of almost compelling people to have more light; and for this reason we can afford to be generous and give electric light credit for its assistance in increasing our sales of gas. In fact, I think I am not magnifying the conditions when I say that, had the people of all the cities required and demanded the quantity of artificial illumination, together with the quantity of gas now used for other purposes than illumination, and the electric light unknown, the gas companies—with the aid of all the present gas-works construction companies, and individuals pursuing that line of business, doing their utmost—would be severely taxed to keep the gas plants of the country in a condition to supply it. Even now some of the larger companies have been forced to make strenuous efforts to keep their works in the necessary condition to get through the winter. I am aware the market price of gas stocks has, at times, suffered from the progress electric light has made and is making; but the business, as a whole, has not suffered, but rather increased.

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* Of Charleston, S. C. Meeting held at Toronto, Canada, October 17, 1888. Reported in American Gas Light Journal, November 2, 1888.

Some gas companies and gas engineers have pursued the policy of, as they say, "fighting" the electric lights. This I regard as a mistaken policy. No gas company or gas manager can afford to stand in the way of the development and march of improvements of any kind. Development and improvement is the order of the day in this age. The world must go forward, onward and upward toward perfection; and the man or men who would endeavor to stop the wheel of progress, in any direction, does or do not comprehend the tendency or drift of things in the age in which we live. The electric light has its advantages. Let us acknowledge them. It also has its defects, which are ample enough to interfere with its progress to that extent which will drive gas from its full share in the business of artificial illumination, to say nothing of its use for heating, which has even now hardly begun.

It may not be improper to remark, that when we stop to consider the persistent experiments and research made, particularly during the last ten years, by men of eminent ability and special education and training for the work, and the amount of money expended in the development of the science of electricity as applied to the production of artificial light since its first introduction, the wonder is that the gas industry is in existence to-day. This fact alone would seem to be sufficient evidence that illuminating gas has qualities inherent in itself; and that when the same energy and scientific ability, together with the experience of the past, are applied to its further development, it must remain, as it has been in the past, the light best adapted, all things considered, for universal artificial illumination and heating.

There are many gas engineers and managers who warmly advocate the policy of amalgamating the business of electric lighting with the gas light business. I must say I am not entirely of that opinion. I can not see why gas companies should engage in the electric lighting business any more than they do in the kerosene oil and candle business, simply because kerosene oil and candles furnish light. At the same time, I am willing to acknowledge that, in some instances, advantages would accrue to both interests if consolidated.

FROM ANNUAL ADDRESS, BY HON. A. M. NORTON, PRESIDENT NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.*

It is not my purpose nor my province to discuss, in detail, the relative merits of gas and electricity for lighting—that subject will be presented most ably by another—but only to offer some suggestions upon the present conditions of the problem with which we are confronted.

Many of us will recall that, a few years ago, under the influence of the claims put forth by the enthusiastic advocates of lighting by electricity, public confidence in gas stocks was seriously impaired, and many of our own number had grave doubts as to the future well-being of the gas industry. Time has greatly moderated the extravagant pretensions of the one class and the fears of

* Nineteenth Annual Meeting, held in Boston, February 20–21, 1889. Reported, American Gas Light Journal, March 4, 1889.

the other, and to-day the relative merits and capabilities of both are better known by that best of all tests—experience. We, as gas men, must recognize the fact that, if the present conditions of both of these illuminating agents remain the same, lighting by electricity has come to stay; for, under certain conditions of place—as theaters, public buildings, squares, and streets—it is a better light than can be furnished by gas to-day. But, in the essential elements of cheapness, reliability, and adaptation to general use, gas retains a decided superiority over electricity. And, notwithstanding the great number of electric light plants that have been established every-where, it would be difficult, and, I think, impossible, to point out a single city or town, in which the consumption of gas for lighting is not steadily increasing, year by year. The electric lamp can hardly be found in a private house to-day, save in those few palatial residences that great wealth has erected. But, even here, gas will be found side by side; and I do not know of a public building of any description that has been erected, whatever the appliances for electric lighting, that does not contain gas pipes also.

Undoubtedly in the future, as in the past, great improvements will be made in the development of gas and electricity as illuminating agents. In reducing the cost of gas, in improving its quality, in perfecting its distribution, and in utilizing the waste products, much has been, and more probably will be, accomplished. Still, after all, I apprehend that this consideration is but a small factor in the rivalry between gas and electricity, and that the decisive victory for the one or the other, as an illuminating agent, is to be won upon an entirely different field. That field is largely comprised in inventions and improvements in burners and lamps. And here we, who represent the interests of gas, with our somewhat conservative ideas, may learn a great lesson from our over-sanguine, perhaps, but certainly energetic, rivals. For the past ten years, some of the brightest minds in the world have given their entire energies to the development and improvement of the electric light; and, as a result, the electric lamp of to-day is two or three times as efficient as that of 1878. This fact alone has made possible the competition between gas and electricity. But the gas burner of to-day, in well-nigh universal use, is the same as that of ten years ago; and, with perhaps a single exception, there has been no marked improvement in the new burners which have successively sought public favor.

Gas and electricity thus stand face to face, competitors for public favor. That competition should be manly and generous; for neither has any thing to gain by depreciating or underrating the merits of its rival. On the contrary, in this wide world of ours, there is opportunity enough and need enough to tax all the capabilities and resources of both. The day is not far distant, when public sentiment will demand, in all of our smaller cities, that the streets be lighted the entire night; and, if this lighting follows the moon, the increased cost will not probably exceed 15 per cent the sunset and twelve o'clock lighting, if gas engines are used. And, so far from there being any hostility or rivalry, prejudicial to the interests of stockholders, between gas and electricity, I know of no good reason why a gas company should not furnish electric lights where they are needed.

Some, perhaps, would not agree with me in this opinion, but it will, I think, be admitted that the current expenses of one corporation will be less than those of two; and, if gas engines are used to supply the motive power, we shall have the most efficient and economical electric plant possible. Undoubtedly to this union some will apply the word "monopoly," or perhaps even a harsher term. And yet, only by serving our respective communities to the best of our ability, can we strengthen or improve our own condition; for the good will that exists between producer and consumer is the most efficient means of benefiting both.

Notwithstanding the competition of electricity, it is probable—almost certain—that, with our increasing population and increasing wealth, the consumption of gas, solely for illumination, will steadily increase, year by year. But, even if, in the future, electricity should displace gas to some degree as an illuminant, and absolutely lessen its consumption for this purpose, the new uses which I have indicated, if they are pressed and developed with energy, will far more than compensate for any loss in this direction. Such is the lesson of all history. A mob attempted to destroy the first labor-saving machine invented in England, for fear that wages would be lessened thereby. The hack drivers of this and of other cities opposed the location of street railways, upon the ground that it would destroy their occupation. Fifty-six years ago, one of the ablest lawyers in New England appeared at the state house in this city, to defend the petition for a charter of a railroad from Boston to Salem, which was opposed by some, who thought, if constructed, it would injure turnpikes, and who cry out against the overhead wires, and would pull them all down. Some day they will be buried underground. Meanwhile, is it not an immense gain for these working-girls to be placed in a quiet, sunny room, far from the maddening engine? In another shop on Broadway, we may see a different arrangement. A two horse-power motor takes its current from an electric light wire in the street, and redistributes its power to shafting placed under the work-tables. Each operator, with a touch of the foot, throws her machine into gear, and takes her share of the two-horse power.

In like manner, it is possible to go to many places in all our cities and find motors of all sizes doing useful work in converting the energy flowing in the street wires into power for driving printing presses, circular saws, elevators, pumps, ventilating fans, and machinery of every kind. It is not so much a question as to what the motor will do as of the convenience of reaching an electric light wire in the street. It is safe to say that to-day there is not a single building being put up for small manufacturing plants where "power to let" is to be painted on the door that is not considering the question between engines and motors. One large building now going up in New York, and intended to be let out with power in small shops on every floor, has no provision whatever for shafts or belts. The engine and dynamos will be placed in the basement, and wires laid in the walls to small motors placed on every floor. Moreover, there being an excess of steam power, the wires will also be laid to the other buildings within a radius of half a mile in every direction. The saving in construction and insurance, and the gain in cleanli ness, quiet, safety, and healthfulness in that neighborhood, will be difficult to measure in dollars and cents.

The electric motor has but one source of danger, and that is the current supplied by the wire. This is no more than the danger from steam-pipes and boilers. Knowing the conditions and limits of safety with steam, we use steam every-where. In like manner, when we learn what are the factors of safety with electricity, we shall use it with the same freedom as we use steam. The condition of safety with the motor is perfect insulation, and this is provided for in all motors, so that practically the new motor is as safe as any of the prime movers from which we derive energy for skillful work.

THE DYNAMO TELEGRAPH PLANT AT PITTSBURG, PA.*

By William Maver, Jr.

A novel, as well as interesting, feature of this instalment is, that the dynamo electric machines used for the supply of electricity for the wires are driven by electric motors which receive their electric motive force from the leads of the "motor" circuit of the Allegheny County Electric Light Company, Pittsburg.

As in the equipment of this new office advantage has also been taken of the experience gained from the previous use of these dynamo machines as generators of electricity for telegraph purposes, and also of the knowledge derived, in other ways, to devise and put into operation some improvements, a description of the whole may not be amiss; more especially as for, perhaps, the first time in the history of the telegraph, dynamo electric machines have also been introduced in that office to supply electro-motive force for the operation on a large scale of "local" circuits.

The electric motors are of ten horse-power each. These motors are attached to the leads of the motor circuit of the Allegheny County Electric Light Company, which circuit supplies, it is said, in all about one hundred motors in Pittsburg. The motors are connected in multiple arc. The electric motor force at their poles is about 110 volts, and when doing their maximum work they give out about 8,800 watts. The motors are compound wound and are self-governing. In actual operation, they show no perceptible variation in running under the ordinary changes in their loads. The motor pulleys are connected by belting to the shafts, on which are carried the pulleys corresponding to the pulleys of the different dynamo electric machines.

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* Reported in The Electrical World.

Usually about three gravity cells of battery are required for office local circuits, and fifteen or twenty-five similar cells for the city local circuits; the local circuits ordinarily have about four ohms resistance, and the sounders used on short city circuits about twenty ohms. In order that these circuits may be operated from the same machine, the local sounders and the city line sounders have been wound to about forty ohms each; and, in addition, a resistance of about sixty ohms has been inserted in each office local circuit to compensate for the line resistance of the city circuits—all of the local and city line circuits being in multiple arc. It is obvious that in a larger office it would be desirable to provide separate machines of suitable capacity for the office circuits and the city circuits, respectively; and this will doubtless be done when dynamo electric machines are more generally used in telegraph offices as sources of electro motive force for the local circuits.

The number of cells displaced in Pittsburg by the main line dynamo machines may be estimated at about 12,000; by the local machines, about 1,100.

In addition to operating these dynamo machines, the motors also supply power to run the blower for the pneumatic tubes between the operating room and the receiving and delivery departments on the ground floor of the building.

This is, perhaps the first and only telegraph office in the world in which there is not a chemical cell of battery employed; and doubtless, also, it is the only office of its kind in which the motive power employed in the operation of the office machinery is electricity. The result is a very neat and well-lighted "battery" room, in striking contrast to the general run of such rooms.

The Western Union office, however, is not the only one in Pittsburg in which the above-mentioned motor circuit of the Allegheny Company is utilized to drive a motor, which, in turn, provides the motive power of a generator of electricity—the Central District & Printing Telegraph Company, of that city, having used that circuit, as I am informed by the general manager of the company, Mr. Henry Metzger, for some time past in the operation of two Sprague motors that drive fifteen generators in the general office of that company. These motors are of one-half horse-power each, and are run twelve hours, alternately. The motors and gearing are fastened on a heavy oak platform 4½ x 9 feet, the whole resting on rubber blocks one inch thick.

The motors are connected by belting with a shaft ten feet in length and one and one-fourth inches in diameter. The generators are mounted on a table composed of an oak plank ten feet long by fourteen inches wide, which is placed about thirty inches above the shaft, and the generators are driven by belts from the shaft. There are no pulleys on the shaft. To facilitate tightening the belts, each generator is fastened to a board twelve inches long by six inches wide, one end of which is made fast to the table by a pair of hinges; the other end rests on an adjusting screw, by means of which the board can be raised and the belt drawn tight. Each generator is connected by a suitable cord and plug to a switch-board, where connection is made with the telephone call wires. In case of a generator failing, the cord and plug attached to the corresponding switch-board is connected to any working generator. Provision is made for the failure of the motors by means of an extra spring-jack switch, which permits the transposition of the cords connected to the generators to a commutator of a thirty-cell Callaud battery.

Another interesting fact in connection with this subject, is that the generators of the Allegheny motor circuit are driven by steam engines whose fuel is natural gas.

It may occur to some to inquire the reason why the leads of the Allegheny Company are not used directly for the supply of electricity for the wires. It is that the potential from those leads is fixed and not sufficiently high for all the requirements. As a matter of fact, however, these leads have been used satisfactorily in Pittsburg, since last year, for the single wires and polar duplex circuits, which do not require over 110 volts potential, this connection having been made immediately after the destruction by fire of that office.

A TWENTY TON TRAVELING CRANE WORKED BY ELECTRICITY.*

By W. Anderson, M. Inst. C. E.

The dynamo, which is considerably larger than is needed for the crane in question, is arranged to give up to 80 amperes at 120 volts, with 1,200 revolutions per minute. The armature is of the cylinder type, field-magnets shunt wound; resistance of armature, .07 ohm, and of the magnets, 75 ohms. It is fixed in the main boiler-house of the works, and is driven by a horizontal engine, having a cylinder 9½ inches diameter, 12 inches stroke, running at 180 revolutions with 50 pounds steam, by means of a link belt. The leads from the boiler-house up to the conductor in the foundry, for a distance of 60 feet, are of 6 B. W. G. copper wire, while the conductor in the foundry is formed of an angle iron bar 2 inches by 2 inches by ¼ inch, extending the whole 350 feet length of the shop; it has one face, roughly ground and protected from rust by vaseline, and is secured to the iron pillars supporting the roof, being insulated by wood blocks. The return current travels along one of the rails on which the crane runs, the joints of the rails being united electrically by copper staples. The motor is one of Messrs. Elwell-Parker's latest types, with single vertical magnet and a drum armature. It is shunt wound, and constructed for 100 volts and 50 amperes. The armature resistance is .056 ohm; that of the shunt, 49.2 ohms. It is fixed on the working platform of the crane, beside one of the main girders. Its driving spindle carries a steel pinion, which gears into a double helical spur wheel, keyed on a shaft which runs longitudinally on the top of the girder, and is connected by nests of three bevel wheels, with friction clutch connections, to the three shafts which command the several movements of the crane, the means of using the hand-power being still retained. Two sets of speed are arranged for each of the movements, namely:

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* Paper read before the British Association at Bath, in section G, September, 1888.

	Slow per min.	Fast per min.
Hoisting.	3.4 feet.	10 feet.
Cross traverse.	25 "	165 "
Longitudinal traverse	78 "	212 "

The handles for operating the several movements, the brake lever, the switch, and the automatic cut-out, are all collected together, so that a single attendant can readily work the crane from one spot.

The crane was set to work in June last, and has continued to act satisfactorily ever since. The advantages of working by electricity are very great, especially in comparison to steam cranes. In large works, a powerful dynamo would be established, and be driven by engines of an economical type. The steam from the main boilers is necessarily always available when the factory is at work, and the current can be easily carried into any part of the establishment. Steam cranes require the attendant to be at his post an hour or more before the works open, water and fuel have to be hoisted on to the crane, and the working is accompanied by dirt, steam, and smoke, the latter especially objectionable with overhead lights, or in shops where bright work is prepared or erected.

The duty realized is about 65 per cent of the power developed in the driving steam engine. As far as can be judged at present, there is no special wear to apprehend. The conductors act satisfactorily, though a considerable length is in the open air, and the dust, heat, and smoke of the foundry do not appear to affect the working.

When first proposed, the writer was not aware of the existence of any other electric crane, but he has since learned that Messrs. Mather-Platt, of Manchester, have had one working satisfactorily for some time, and that there is one also in France.

ELECTRIC POWER TRANSMISSION IN SWITZERLAND.

A plant has been erected in Piovene, near Schio, in upper Italy, to the order of Signor Gaetano Rossi, and serves to carry the power given off by a 250 horse power American "Victor" turbine, in the valley, to a mill situated on a neighboring hill. It was partly on account of the great difference in level between the turbine house and the mill that electric transmission has been adopted, teledynamic transmission becoming very difficult when the position of the ropes deviates much from the horizontal. The total distance between generator and motor is nearly 500 yards, and the guaranteed commercial efficiency of the plant is 78 per cent.

That the electric transmission of energy has now become a most important branch of work, in Switzerland and other countries where water power is abundant, will be seen from the following list of installations which have been erected, or are in course of erection, by the Oerlikon Maschinenfabrik:

Name of Installation.	Horse Power.	Distance. Meters.
J. Mueller-Haiber, Solothurn	50	8,000
Gaetano Rossi, Piovene, Italy.	250	450
The Worsted Yarn Mill of Derendingen, Switzerland.	280	1,300
J. Amman & Wepfer, Pordcone, Italy	60	1,000
Troller Bros. & Co., Lucerne	120	3,000
R. & M. Frei, Aarau.	15	1,000
J. & M. Legler, Diesbach, Switzerland.	120	600
Paper Mills, Steyrermuehl-Aichberg, Austria.	100	600
C. F. Bally, Schoenenwerd, Switzerland (combined with electric lighting),	12	500
Bay & Co., Steinbach-Berne.	15	1,300
J. Rauch, Muehlau, near Innsbruck	50	600

ELECTRIC MOTORS IN MINING.*

An instance of electrical power already in use in mining—and meeting the requirements of fulfilling the conditions for such work—is the installation of the enormous plant at Big Bend, on the Feather river, Butte county, California. A waterfall of 300 feet was obtained, and at this point are placed powerful Pelton wheels, giving a very large horse power. The electric generators put in here furnish current along a circuit of eighteen miles, extending around the entire bend of the river. Motors are placed along the circuit at fourteen different points, and furnish power required for hoisting, pumping, and running machinery. Another mining application has been made at Aspen, Col., where an electric motor is applied to hoisting purposes. The hoisting machine consists of the usual drum, mounted on a shaft, carrying a friction wheel. A parallel shaft carries a paper-faced friction pulley, bearing against the iron face of the friction wheel. For reducing the speed, intermediate gears mesh into pinions on each end of the armature shaft. Voltage, 440; dynamo a mile off. Two hoists of this kind are to be operated on the circuit, besides a ten horse power motor of standard shape. The Aspen company has effected a large saving in cost of haulage, hoisting, and pumping, by its electric plant, and has ordered several more machines. Plans are also being perfected for a large central power station, to be run by water power, the energy to be transmitted electrically to other mines in the district. In this connection, it may also be mentioned that a large coal and coke company, at Glenwood, Col., is putting in an electric plant, to utilize the energy of a 470 feet head of water, and carry the power three miles away. At Silver City, Idaho, a motor is operating a 50-stamp mill, four miles away from the water power that drives the generating dynamo. These stamps, as we stated a short time since, have forty drops a minute, and a dead lifting weight of 6,000 pounds to a battery, the total energy required being 75 horse power. By this plant, the manager of the mill saves $90 a day on haulage alone. Some idea also of what may be done in converting non-paying mines into highly profitable ones, may be formed from the instance in New Zealand, where a gold mine has been rendered valuable, by transmitting the power to it from a waterfall by electricity, in an air line over the top of an intervening mountain 2,000 feet high. Of course, there are various classes of work to be done by the motors besides stamping, such as the electric hoists built for a mine at Aspen, Col.

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* Modern Light, Heat, and Power.

ELECTRIC POWER IN THE COMSTOCK MINES.*

The Nevada mill is installing a plant, consisting of two dynamos and motors of an improved pattern, that will be able to put upon the stamps 80 per cent of the power generated at the bottom of the shaft. There are to be six dynamos, one always to be held in reserve, and six Pelton wheels, 40 inches in diameter, to be made of phosphor bronze, to drive them, each attached to the dynamo shaft direct. These wheels will be set up at the tunnel level of the mine, in a large chamber already prepared to receive them. A column of water, brought down the side of Mount Davidson in a wrought iron pipe, will be delivered, through a proper nozzle, upon the surface of the wheel which stands in the mill, under a perpendicular pressure of about 460 feet. This wheel is 10 feet 10 inches in diameter. After the water leaves the wheel, it is piped to the main shaft of the Chollar mine. Down this shaft (and the incline at its bottom) the water is conveyed in two pipes to the electric chamber on the tunnel level. The water will be put upon six wheels, under a perpendicular pressure of 1,630 feet. In no place in the world has water been used on a wheel under such a tremendous head. The water will be delivered upon each wheel, through a nozzle somewhat less than half an inch in diameter. Each wheel is intended to develop about 125 horse power. This will make a total of some 750 horse power delivered by the six wheels. As this is the first attempt in the history of mechanics to operate water wheels under such an enormous pressure (as well as the fact of the utilization of the power by electrical transmission), the result of the experiment will every-where be anxiously awaited.

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* From The Mining Industry.

ELECTRIC TELPHERAGE FOR MINES.

Telpherage roads, operated by electricity, are now in use for mining work. The road or overhead track consists of two stationary steel cables, suspended, one above the other, between posts of wood or metal, fifty feet and upward apart, and at such an elevation from the ground as not to interfere with surface traffic. The cars run on wheels, and are suspended between the upper and lower cables, the upper cable carrying most of the weight. The upper cable is charged with a positive, and the lower with a negative, current of electricity. By contact of the wheels with the cables, the current is conveyed to an electric motor in the car, which imparts motion to the wheel by gears, etc.. These cars can be of any pattern, dimensions, or material required by the service. They can be run at a rate of from four to twenty miles an hour. Such a system is simple and practical. It is economical to build, operate, and maintain. It is above mud and floods; can cross streams, canons, or marshes without bridges; and the cables are not affected by rain, snow, or ice. Its adaptation to mining work is such that its use in many localities would cause a large reduction in working expenses, and often make the difference between success and the want of it.

ELECTRIC HOISTS FOR MINE INCLINES.

One of the large incline hoists, operated by electric motors, built for the Roaring Fork Electric Light and Power Company, of Aspen, Colorado, for use in the mines there, has been put into successful operation. This hoist is used for hauling empty cars into the "Veteran" tunnel. The loaded cars run out by gravity. The motor pulls the empty cars into the tunnel, in trains of six each, at the rate of 500 feet per minute, and with perfect ease. The distance is 1,000 feet, the grade 3 per cent, and the weight of a train 45,000 pounds. As soon as the incline can be timbered, the other hoist will begin its service.

ELECTRIC RAILROADS.

Probably no application of electric power has attracted closer attention from those whose interest is affected by it than its use for operating street railroads. In no other branch of service is electric power destined to win a more brilliant success. In this service electric power is brought in daily contact with thousands of people, and gives them a practical lesson as to its safety and the ease with which it can be controlled. The following is but one of many items that can be furnished to illustrate this point:

ELECTRIC MOTOR CARS CARRY 15,000 PEOPLE A DAY.*

What electrical railways can do, and are doing, will electrify the average reader at first hearing, and he will instinctively entrench himself in incredulity, shouting the familiar slogan, "reporters' yarns." But facts are stubborn things, and an official report of the superintendent of the Seashore Electric Railway, Asbury Park, N. J., comes from too competent an authority, and is too easily verifiable to leave the skeptic the slightest excuse for shutting himself up in his bastion.

Such a report was received on August 16th, and was to the effect that, on the preceding day—the occasion of the Republican League Convention of the State of New Jersey, Asbury Park—15,000 passengers were carried by the Seashore Electric Railway without the slightest accident of any kind, and without any delay. This was done with sixteen motor cars, and the average number of passengers per car was nearly 940. How is this for electrical propulsion?

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* From Electrical Review.

Rapid as has been the progress in electric railroad service, it is not comparable with that which is yet to come. Hundreds of street railroad companies have been waiting to see how electric motor cars would perform their service through all the variety of conditions afforded by the seasons of an entire year. The difficulty of contending with snow on the track has been conceded by all street car men to be the most trying obstacle with which the motor car would meet. That difficulty easily overcome, settles the question of the adoption of electric motor power by all the street car roads in the country. The change will not be a development. It will be a transformation. On a point like this, a report from one or two places is sufficient. I have selected the following

ELECTRIC CARS AS SNOW DEFIERS.*

The operation of electric cars this winter, despite heavy storms and snows, has been matter of general congratulation in electrical circles, where, even by the most sanguine, such good results were hardly expected. Scranton, Pa., which is now one of the most electrical towns in the country, has just furnished another example of victory over snow on one of its many electric roads.

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* From Electrical World.

On Saturday, January 20, there was a heavy fall of snow in Scranton, Pa., which, at 9 P. M., had accumulated to a depth of about six inches. On Sunday the cars made regular trips, which on that day are run hourly. On Monday morning it was found that there were many drifts, but those seemed to offer no impediment to the first car to go over the line, which plowed its way through them in a way that left no doubt as to the ability of these cars to operate in stormy weather. On grades of 4½ and 5 per cent the snow was even deeper than on a level; but in spite of this the cars made their trips on schedule time. The operation of the cars was the subject of universal favorable comment. At Des Moines, it may be added, in the middle of December about a foot of snow fell, but it had no effect on the electric cars, which made their regular trips every fifteen minutes. In fact, it was, it is said, the only tramway in Des Moines which was able to operate on schedule time during the storm.

A MOUNTAIN ELECTRIC RAILWAY.*

An electric mountain railway—the first of its kind—has recently been opened to the public at the Burgenstock, near Lucerne.

Hitherto it has been considered imposible to construct a funicular mountain railway with a curve, but the new line of the Burgenstock has achieved that feat under the superintendence of Mr. Abt, the Swiss electrical engineer. The rails describe one grand curve formed on an angle of 112 degrees, and the journey is made as steadily and as smoothly as upon any of the straight funiculars previously constructed. A bed has been cut, from the most part out of the solid rock, in the mountain side, from the shore of the Lake of Lucerne to the height of the Burgenstock—2,330 feet above its level, and 2,860 feet above the level of the sea. The total length of the line is 938 meters (about 3,050 feet), and it commences with a gradient of 32 per cent, which is increased to 58 per cent after the first 400 meters, and this is maintained for the rest of the journey. A single pair of rails is used throughout, with the exception of a few yards at half distance to permit two cars to pass. Through the opposition of the Swiss government, each car is, at the present time, only allowed to run at half distance, and they insist upon the passengers changing, in order, as they say, to avoid collision or accident. A number of journeys were made up and down the mountains in company with the engineer, and the experience is sufficient to prove that the prohibition is altogether unnecessary. The motive power, electricity, is generated by two dynamos, each of 25 horse power, which are worked by a water-wheel of 125 horse power, erected upon the River Aar at its mouth at Buochs, three miles away. Only one man is required to manage the train, and the movement of the cars is completely under his control. One dynamo is sufficient to perform the work of hauling up and letting down the cars containing fifty or sixty persons. At the end of the journey, completed in about fifteen minutes, at an ordinary walking speed, the car moves gently against a spring buffer, and is locked by a lever, without noise and without jolting the passengers. This interesting undertaking has been carried out at a cost of $125,000.

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*London Daily News.

ELECTRIC RAILWAYS IN AMERICA.*

Now in Operation.

LOCATION.	OPERATING COMPANY.	Length in Miles.	Number of Motor Cars.
Akron, O	Akron Electric Ry. Co	6.5	12
Allegheny, Pa	Observatory Hill Passenger Ry. Co	3.7	6
Ansonia, Conn	Derby Horse Ry. Co	4.	3
Appleton, Wis	Appleton Electric Street Ry. Co	5.5	6
Asbury Park, N. J.	Seashore Electric Ry. Co	4.	12
Asheville, N. C.	Asheville Street Ry.	3.	4
Baltimore, Md.	Baltimore Union Passenger Ry. Co	2.	4
Binghamton, N. Y.	Washington St. Asylum & Park R.R.	4.5	8
Boston, Mass.	West End St. Ry. Co., Brookline Br'ch.	12.	20
Brockton, Mass.	East Side Street Ry. Co	4.5	4
Carbondale, Pa.	Carbondale & Jermyn Street Ry. Co	5.	3
Cincinnati, O.	Mt. Adams & Eden Park Incline Ry Co.	1.	3
Cleveland, O	East Cleveland R.R. Co.	23.5	16
Columbus, O	Columbus Consolidated Street Ry. Co.	2.	2
Crescent Beach, Mass.	Lynn & Boston Street Ry. Co	1.	1
Davenport, Iowa	Davenport Central Street Ry. Co.	3.5	8
Danville, Va	Danville Street Car Co	2.	4
Dayton, O	White Line Street R.R. Co.	8.5	12
Des Moines, Iowa.	Des Moines Broad Gauge Ry. Co	7.5	8
Detroit, Mich	Detroit Electric Ry. Co.	4.	2
" "	Highland Park Ry. Co.	3.5	4
Easton, Pa	Lafayette Traction Co	1.	2
Fort Gratiot, Mich	Gratiot Electric Railway	1.75	2
Harrisburg, Pa.	East Harrisburg Passenger Ry. Co.	4.5	10
Hartford, Conn.	Hartford & Weathersfield H. R.R. Co	3.	2
Ithaca, N. Y	Ithaca Street Ry. Co	1.	2
Jamaica, N. Y	Jamaica & Brooklyn R.R.	9.	10
Lafayette, Ind	Lafayette Street Ry. Co	2.25	8
Lima, O	Lima Street Ry. Motor and Power Co.	6.	7
Los Angeles, Cal	Los Angeles Electric Ry. Co.	5.	4
Lynn, Mass.	Lynn & Boston Street Ry. Co.	2.25	2
Mansfield, O	Mansfield Electric Street Ry. Co	4.5	5
Meriden, Conn.	New Horse Railroad	5.	12
" "	Meriden Horse R.R. Co	5.	12
New York, N. Y.	N. Y. & Harlem (Fourth Av.) R.R. Co.	18.5	10
Omaha, Neb.	Omaha & Council Bluffs Ry. & R'ge Co.	9.	12
Pittsburg, Pa.	Pittsburg, Knoxville & St. Clair St. Ry.	2.25	..
Port Huron, Mich.	Port Huron Electric Railway	4.	6
Reading, Pa.	Reading & Black Bear Railway	1.5	2
Revere, Mass	Revere Beach Ry. Co.	1.	1
Richmond, Va.	Richmond Union Passenger Ry. Co	13.	40
Salem, Mass.	Naumkeag Street Ry. Co	1.75	6
San Diego, Cal.	San Diego Street Ry. Co	9.	4
San Jose, Cal.	San Jose & Santa Clara R.R. Co.	10.	6
St. Catherine's, Ont.	St. Cath., Merritton & Thor'd St. Ry. Co.	7.	10
St. Joseph, Mo	St. Joseph Union Passenger Ry. Co	9.75	13
" "	Wyatt Park Ry. Co.	5.	10

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* Electrical Engineer, February, 1889.

ELECTRIC RAILWAYS IN OPERATION—Continued.

LOCATION.	OPERATING COMPANY.	[illegible] in Miles.	[illegible]
Scranton, Pa	The People's Street Railway	1·	[illegible]
" "	Scranton Suburban Ry. Co	1.	10
" "	Nayang Cross-Town Railway		1
" "	Scranton Passenger Railway.	[illegible]	1
Syracuse, N. Y ...	Third Ward Ry. Co..	1	[illegible]
Washington, D. C....	Eckington & Soldiers' H. Elec. Ry. Co	[illegible]7	[illegible]
Wheeling, W. Va...	Wheeling Ry. Co..	[illegible]	[illegible]
Wichita, Kan.........	Riverside & Suburban Ry. Co.	7	[illegible]
Wilkesbarre, Pa... ..	Wilkesbarre & Suburban St. Ry. Co.	[illegible]	7
Wilmington, Del....	Wilmington City Ry. Co.	[illegible]	[illegible]
Windsor, Ont.. ..	Windsor Electric Street Ry. Co..	1.5	2

TOTAL ROADS ...58 TOTAL MILES .308 TOTAL MOTOR CARS. 121

Construction or Under Contract.

Alliance, O.. ..	Alliance Street Ry. Co.	2.	3
Atlanta, Ga	Atlanta & Edgewood Street Ry. Co .		
Atlantic City, N. J ..	Pennsylvania R.R. Co.	5.	6
Bangor, Maine	Bangor Street Ry. Co	5.	4
Boston, Mass	West End Street Ry. Co., City Line, Boylston and Beacon Streets.		
" "	West E. St. Ry. Co., Harvard Sq. Br'ch.	14.	20
Chattanooga, Tenn....	Chattanooga Electric Street Ry. Co	5.	6
Cincinnati, O	Cincinnati & Incline Plane Railway	6.5	20
Cleveland, O	Brooklyn Street Ry. Co.	10.	10
Erie, Pa..	Erie City Passenger R.R. Co	8.5	20
Hudson, N. Y	Hudson Street Ry. Co	2.5	3
Lincoln, Neb	Lincoln Cable Ry. Co	5.	10
Louisville, Ky.	Central Passenger R.R. Co		10
Manchester, Va....	Richmond & Manchester Ry. Co .	3.5	10
Minneapolis, Minn. ..	Minneapolis Street Ry. Co	69.5	8
Nashville, Tenn	McGavock & Mt. Vernon Street Ry	3.6	
New York, N. Y.. ..	North & East Rivers Ry. Co	3.	20
North Adams, Mass..	Hoosac Valley Street Railway ..	5.	6
Ontario, Cal	Ontario & San Antonio Heights Ry. Co.	8.	4
Ottawa, Ill.	.. ..	6.	8
Port Chester, N. Y...	Port Chester & Rye Beach St. Ry. Co.	3.	5
Richmond, Va	Richmond City Ry. Co	7.5	50
St. Louis, Mo	Lindell Ry. Co		1
Sault Ste. Marie, Mich.	Sault Ste. Marie Street Ry. Co	2.	
Sandusky, O . ..	Sandusky Street Ry. Co ...	4.	6
Seattle, Wash. Ter.....	Seattle Electric Railway & Power Co.	5.	5
South St. Paul, Minn..	South St. Paul Rapid Transit Co .	8.	10
Southington, Conn...	....	2.2	..
Springfield, Mo..	....	2.	..
Steubenville, O.. ...	Steubenville Electric Ry. Co .. .	2.5	10
Tacoma, Wash Ter....	Tacoma Street Railway	5.	4
Topeka, Kan	.. ..	14.	30
Worcester, Mass .. .	Worcester & Shrewsbury	2.7	..

TOTAL ROADS 33

A CURIOUS SOURCE OF POWER.

The curious source of power for some of the dynamos of the lighting plant connected with the Ponce de Leon Hotel, at St. Augustine, Fla., is an artesian well, the water of which drives the dynamo. That installation, however, does not stand alone; being equaled, if not exceeded in its remarkable character, by the installation of the Yankton Electric Company, of Yankton, D. T. The source of power there is a flowing well 600 feet deep. The water comes up through a six-inch casing and passes into an old boiler, which acts as a trap to catch the stones which are sometimes thrown up by the well. A pipe leads to a twelve-inch Fleniken turbine, with a fall of thirty feet. The turbine, which is controlled automatically by a Pritchard electric governor, drives the dynamos.

The pressure in the boiler is seven pounds under full head, and fifty-seven pounds to the square inch when the well is closed.

PART II.

SHOULD A CITY OWN AN ELECTRIC CENTRAL STATION?

This question opens the whole subject of social and political economy.

The fundamental principle of city government is, that the municipal authorities shall exercise such powers only as are delegated to them by the representatives of the people acting through State legislation. The object of city government is to secure, through corporate action, benefits that cannot be secured by private means.

These benefits are the promotion of the welfare of the people by protecting life and property, enforcing sanitary regulations, constructing and maintaining public highways, and providing the means of education. These objects are not commercial or productive in an economic sense, and, therefore, are not prosecuted for the purpose of making a profit.

Municipal capital is taken from the earnings of the people. Those acts of legislatures which authorize the taking of the people's money by municipal authority, for the purpose of investing it in commercial or productive undertakings, to be managed without a profit, in competition with private enterprise, are not in accord with the well-established principles of a sound political economy.

Profit-making is the essential object of all industry. When a city enters the business of supplying the material necessities of the people, and conducts the business without designing to make a profit, it destroys all motive for private capital to undertake the same line of business. The logical sequence is, that a city must do all the business in the line it undertakes, and do it in perpetuity, or allow private capital to do it without competition from the municipality.

Government is an absolute monopoly. If it may monopolize one line of business, it may monopolize all business. For this reason, every citizen's interest is deeply touched by the question, whether a city should own an Electric central station. Does he want the principle established, that a municipality may undertake a business that is essentially commercial, and manage it without designing to make a profit, in competition with private capital? Is he willing to be taxed to enable the city to secure capital to be used for such a purpose? If this principle is established, where will the line be drawn? If a city may do the lighting business, why not the telephone, street-car, power, or any other business requiring large capital? It can get its capital by taxation. It does not have to pay taxes or interest, nor does it have to make a profit; therefore it can render cheap service. If it does borrow its capital on its bonds, it simply takes authority to tax the people twice for the same amount—once for the principal and once for the interest.

If a city's business is managed as well as that of private persons or companies, whatever it chooses to do can be done at a less cost, owing to the elimination of all charges for taxes, interest or profit, than is possible for private enterprise. Its competition, working without profit, reduces private enterprise to the condition of the slave that works without hope of reward. A city operates all it undertakes on the prison-labor system—simply to make the institution self-sustaining; and it has the power to mortgage all the property in the city to make good any deficiency.

The question, "Should a city own an Electric central station?" viewed from the standpoint of the interest of the citizen, and kept within the narrow limits of a question of policy only, can be answered in the negative, without fear of successful contradiction.

NO CITY CAN AFFORD TO OWN AND OPERATE AN ELECTRIC CENTRAL STATION.

In maintaining this proposition, it may be conceded, for the sake of the argument, that the business, if owned by the municipality, would be managed as satisfactorily and economically as by a private company, and that there would be no tendency to use the patronage growing out of it as a plum for political spoils.

In sustaining the proposition, it will be first shown that the saving supposed to accrue from public ownership *is not real.* To illustrate this the estimate made for the city of Detroit, as given in the report of its Lighting Committee, adopted July 17, 1888, will be accepted as correct, and made the basis of the argument.

This report, stated briefly, is, that the lighting of the city of Detroit can be done with 1,000 Arc lamps; that the plant will cost $350,000; that it can be bought with four per cent. bonds, and that it can be operated, including the interest on bonds, for $92,000 per year, making the average cost $92 per lamp. It also states that the present expense for lighting is $193,690, and that the city, by owning and operating an Electric central station plant, can save $101,690 per year.

As presented, this is a scheme to take $350,000 of the citizen's money, and invest it in commercial business, without a design to make a profit. Until this is done, $14,000 per year of the citizen's earnings must be taken to pay the interest on bonds. This payment is a profit to the bondholder for the use of his money. This infringes the principle of corporate ownership. As long as the bonds are unpaid the plant is really owned by private capital, but is operated by the city under a lease guaranteeing four per cent per annum profit to the bondholders. To be logical, the scheme should be to levy a tax to raise the full amount necessary to pay for the plant at once, so that the city might own it, and then to operate it without a profit, thus saving $14,000 per annum more. This suggestion will, of course, be met with the statement that money is worth more than four per cent to the citizens, therefore it is better policy to borrow the money with which to pay for the plant at four per cent than to levy a tax for the full amount at once. This plea admits the plea that the interests of the citizens, in their private capacity, is greater than their interests in their municipal capacity.

If money is worth more than four per cent to citizens, why take any of their money with which to buy the plant? The reply is, to save them $101,690, the difference in cost between lighting the streets as it is now being done, and as it would be done if the city owned the plant. A valid reason, *if true.* To prove the truth of this claim, it must be shown that there is no way in which the saving can be effected, except in the way proposed.

It must be conceded that the corporate interests of a city can not be served at the expense of the private interests of its citizens.

Every responsible citizen pays two lighting bills; one his private bills, the other his tax bill. The income usually received by gas companies for municipal lighting represents about one-sixth of their total income from lighting service. This shows that when a citizen pays

$1.00 for public lighting he pays $5.00 for private lighting. His interest in the price of private lighting is therefore five times as great as his interest in the price of public lighting. This larger interest of the citizen is untouched by the report of the lighting committee.

A calculation on the basis given shows that the citizens of Detroit are paying $1,162,140 per year for lighting. If the profit on the public lighting is $101,690, and it is taken away from private enterprise by a municipal plant, and through doing this the city loses an opportunity to secure a ten per cent reduction on the cost of private lighting, or gives reason for a ten per cent increase on that price, how much will the citizens of Detroit save by consenting to be taxed to enable the city to go into the lighting business on its own account?

Councilmen have been known to argue that in letting contracts for public lighting they were not bound to consider the question of the cost of private lighting; that they must make as good a bargain as they could *for the city*, as though they represented the city and not its citizens. Under the influence of such arguments, contracts for public lighting have been made at very low prices, but under conditions which left the citizens no recourse but to pay high prices for their private service; so that as an actual result, the lighting service as a whole, cost them thousands of dollars more under the terms of the low public contract than it would have done under the terms of an offer asking a higher price for the public service and fixing a lower price for the private service.

There can be no competition in the Electric service of a city. Such a service can not be developed to the point of greatest efficiency and economy unless it is owned by an undivided management. There must be a limit to the wires strung overhead, or to conduits laid under streets. If the entire Electric service of a city is controlled by one ownership there will not be a single unnecessary wire run, nor any fault in the service through the unnecessary crossing of lines.

The Electric service of a city is a business which citizens can not undertake individually. It must use the streets and alleys for its lines of distribution. In these respects it resembles the street car service. There is more reason for a city to go into the street railroad business, all of which is done on streets over which it has complete control, than into the lighting business, five-sixths of which is done on private premises over which it has no control. If saving money is the only consideration, the operation of all street car lines at rates of fare not designed to pay taxes, interest, or profit, would, in the assumed sense of the term, save many thousands of dollars more than can be saved by doing public lighting only, on a similar basis. To be logical, the saving should be undertaken where there is the best chance for it and where its amount will be largest.

The business of Electric service however, can not be compressed within the narrow limits of street lighting, nor yet within the broader limits of public and private lighting, comprehending the entire lighting service of a city. It includes this and the power service as well. The power service represents an interest immeasureably greater than that of lighting. A lighting service can employ a plant to its full capacity but four hours out of twenty-four; while a power service can so employ it ten hours out of twenty-four. The two services combined, can give a plant profitable employment every hour out of the twenty four. The united service can be performed at a less rate without decreasing profits than any part of it could be rendered by itself. Following out the basis of calculation, the private lighting being five times that of the public lighting, and the power service being two and one-half times that of the lighting service, the result will show that a saving of ten per cent on the combined light and power service would be equivalent to an annual saving of *more than the* entire cost of the plant which the lighting committee has recommended the city of Detroit to buy. Does not this prove beyond all question, that if saving is the true consideration, the true way in which to effect it, is by concentration, not by the division of the Electric service.

The Electric service is essentially a business for a private monopoly. The monopoly should be created under conditions of control which will enable municipal authority to secure all the benefits sought. It is plain that no municipality can enter upon the commercial business of supplying light and power wherever needed, including operating street railroads. A plant capable of doing this, in the city of Detroit, will cost several millions of dollars instead of $350,000. When fully installed under proper conditions its services can be rendered at rates which, as a total result, will save the citizens of Detroit infinitely more than is claimed as a possible saving through the city owning a street lighting plant, and at the same time the service itself can be of a character to add advantages of incalculable value in their benefit to the health, comfort and industry of the people.

When this subject is fully understood, it will be seen how superficial has been the view of those who have thought they could benefit either the citizens, the city, or the Electrical industry, by dividing the Electric service of a city between municipal and private plants, or by placing the lighting part of the service only under municipal ownership. The saving supposed to be effected by such a course is simply a work of the imagination.

In the second place, it can be made clear that if the saving represented is actual, it is not secured in the better way.

If a city buys a plant, it must own and operate it in perpetuity. This is a very different condition from that under which a private company has been asked to contract to do the public lighting. Such contracts are usually made, under a misguided idea of economy, for one, three, five, or it may be ten years, thus robbing them of their most valuable feature, perpetuity. If, at the conclusion of a short term contract, a private company fails to secure a renewal, and its plant is left upon its hands unused, what would become of the large profit that this Detroit estimate shows it has been making? If the city of Detroit buys a plant and operates it three years, according to the terms of this estimate, and realizes all the saving there shown, and at the end of three years discontinues the use of the plant, what would become of its saving? The element of risk of renewal is a powerful factor in increasing the cost of public lighting. That element can be removed and the saving effected without taking one dollar of the people's earnings, to be invested in a business without design to pay taxes, interest, or profit.

If a city will offer a private company a contract in perpetuity, at the same price a careful estimate would show the cost of operating an isolated plant for street lighting only, it will find abundant private capital to undertake the service; therefore, it is not necessary for a city to buy a plant to secure the service at that rate. Such a contract could provide that additional lights could be added as needed, at the same pro rata of expense; so the future as well as the present will be provided for, without investing money, raised by taxation, in a commercial business. The contract could also stipulate that in consideration of the franchise being perpetual and exclusive, the company should furnish Electric light and power wherever needed. This would be a first class monopoly. Like all such privileges, it could secure the investment of large sums in the best apparatus and construction, and render service at less rates than have been known under the short lease and competitive system.

A close examination of this subject will show that the high rates that have been charged for Electric service, have been occasioned by unsound economic theories, rather than by overcharging. It will show how superficial is the view which asks a city to assume a debt of hundreds of thousands of dollars, and impair a service of vital importance, to effect a saving which can not be secured in that way, but which can be secured beyond all contingency with a few strokes of the pen, by granting franchise and contracts, in strict accord with the acknowledged principles of sound political economy.

There can be no permanent competition in the Electric service of a city. If, by reason of its great size, a city shall succeed in getting a few separate companies to undertake its Electric service, they will quickly agree on their rates; that will be the end of competition.

There can always be a comparison of rates between cities of corresponding size. If a franchise and contract is made perpetual and exclusive, it should contain a provision, securing to the municipality the authority to adjust the rates charged for all branches of the Electric service, so the price shall not exceed that paid in any other city in the United States, where the same service is rendered under similar circumstances. This will secure for it the power always to obtain for the city and its citizens efficient Electric light and power service, at reasonable rates, and will effect a saving on the total amount of business done, many times greater than can be made by the city owning a plant for street lighting only.

A third view of this subject is in its relations to small cities. If it is a question of debatable policy, for the larger cities to own and operate an Electric central station for public lighting, such a course is positively fatal to the proper development of the Electric service in small cities. In such cities, on account of the limited amount of the total business, it is absolutely necessary to concentrate it all under one ownership, to secure any thing approaching the highest degree of efficiency and economy. Says the report of the Detroit Lighting Committee: "The entrance of municipalities into the field of Electric lighting, is comparatively a new element of competition, and has thus far been almost exclusively confined to smaller places, which have required smaller plants and lesser outlay."

What is the character of this "new element of competition?" It is the raising of money by taxation, to be used in an essentially commercial business, without the intention of paying taxes, interest or profit, and for the avowed purpose of driving private capital out of the business. *This is not competition, it is communism.*

In the appendix of this report, reference is made to sixteen cities that have bought small Arc light plants for street lighting, and to four that are talking about doing so. One of the sixteen, reports an experience unfavorable to public ownership. But two out of the sixteen report renting commercial lights. None of them make any mention of lighting for domestic use. According to these reports the people are highly elated with the success of their town plant, and think they have "the best lighted city in the world." If the report read, "the best lighted city in *our* world," it would undoubtedly be corrrect, for that of which there is no knowledge does not exist.

In none of these reports is there any thing to show that the idea has ever entered the thoughts of the writers that a city is not composed of streets only, and that to have a well-lighted city, the places of business and homes of the people must be well lighted.

There is nothing to show that any person having any thing to do with these réports ever conceived a comprehensive idea of what should constitute the Electric service of a city, and what it is capable of accomplishing for the people. There is no suggestion in them as to how the people are ever to secure the benefits of Electric light and power for their private nse.

Not many years can pass before the progress of events will satisfy cities that have taken the ill-advised action of buying an Electric central station, that, instead of gaining an advantage, they have created an obstruction to the proper development of the Electric service. To secure the full advantage of that service, they will, sooner or later, sell their plants to private companies, who will operate them under contract in connection with the private light and power service.

This consideration of the subject may be briefly reviewed as follows: The only reason that justifies the purchase of a plant by a city, is, that by so doing money will be saved for the people. The basis for the saving claimed is established by comparing the cost of street lighting done by private companies, on short contracts, with the cost of operating a public plant in perpetuity, without its paying taxes, interest or profit. The claim is made without considering the effect of separating the street lighting from the private electric service, or the effect of the separation on the price of private lighting. No consideration is given to the saving that can be effected by granting franchises and contracts in perpetuity, as compared with the policy of granting franchises and short contracts, with the view of securing competition. No weight is given to the fact that, when a municipality enters the business, it secures an exclusive franchise and contract in perpetuity, without offering private capital an opportunity to compete with it on the same terms, and then the claim is made that all saving secured is due to public ownership.

All profit or saving shown by such superficial views of the subject, when tested by broad and well-established principles of political economy, prove to be unreal.

If the people of a city desire to secure the most efficient Electric service at a fair price, there is but one way to do it.

1. To organize a responsible private company on a basis sufficiently broad to enable it to supply the entire Electric requirements of the city for light and power.

2. To cause the council to grant the company a perpetual franchise and contract for public lighting.

3. To qualify the franchise and contract with the provision that the service shall be rendered to the city and its citizens at a price, to be adjusted every fifth year, not to exceed the price of similar service in other cities of corresponding size in the United States, where the service is rendered under similar circumstances.

4. To stipulate that the company shall furnish, under these conditions, Electric light and power, as may be required at any point in the city.

Such measures will guarantee permanency of tenure, and will induce the investment of private capital on the most advantageous terms in a complete Electric service. When a city has secured such a service, its people will enjoy all the benefits to be derived from *the new era of Electric light and power.*

MUNICIPAL OWNERSHIP OF COMMERCIAL MONOPOLIES.*

Since the day when Hermes Mercurius Trismegistus went up into the Mount of Regeneration, with his son Tat——, to recite his secret sermon, it has been clear to all thinking minds, that by the use of terms, the people are deceived.

Much has been written and many papers have been read before important bodies, by those favoring "Municipal Ownership of Natural Monopolies." The title they assume for their subject is misleading. Its true name, designating accurately the economic principle which it advocates, is *Municipal Slavery*—a scheme to enslave Capital and pauperize the people.

The economic principle advocated is not in accord with natural economic law; therefore, it is an obstruction to the progress of civilization.

You who are here assembled know that all progress is due, and must ever be due, to the discoveries of science being made available for the uses of man. There is but one science—the science of natural law. The nearer its devotees or investigators arrive to an understanding of natural law, the nearer they apprehend the truth. Actions guided by truth are the guarantors of benefactions.

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* Read before the National Electric Light Association at its Ninth Semi-Annual Convention, Chicago, February 21, 1889.

You who have experimented, with great patience and at great cost, to discover the natural laws governing the generation and control of Electric Energy, know how impotent all your devices are to compel that energy to serve you, if they fail to comply with the conditions of those laws. The same fact is true in economic science. If economic policies do not correctly apprehend and comply with natural economic laws, then the effort made is impotent to secure the best economic results.

Public ownership of Commercial Monopolies is advocated upon the supposition that, if worked without a profit, the economic result will be a benefit to the people. Work without profit is slavery. That slavery is not an economic benefit, is proven by the experience of all men in all ages.

A man is foolish that expends time and money in an attempt to invent a thing that he can find ready made. A Community is foolish to undertake an economic policy that all the data of the human race proves to be wrong; a policy which, in the very nature of things, must be absolutely wrong.

That Capital is entitled to a profit for its use and risk, is the foundation law of all economic science. There is not a recorded instance in the history of finance, where an interference with the operation of this law has secured a permanent benefit for the people. All evidence shows that, where this law is allowed to operate with the greatest certainty, there Capital is most abundant, works on the smallest margin, and induces the most healthful progress.

Capital is the conserved energy of individual action; it never loses its individual character.

When the attempt was made to christianize Communities by Government Authority, they remained barbarians. When Communities attempt to become rich by operating Commercial Monopolies without a profit, they will be made paupers. Religion is individual rightness. Capital is individual energy, conserved for individual betterment. Civilization makes progress through individuals becoming better and richer.

A man's capital is his power to produce. Surplus is the product of energy in excess of the wants of life. Capital is the conserved energy of surplus. Surplus is an individual creation, and belongs by natural right to its Creator. To abrogate the law of increase for use and risk, is to destroy the only economic inducement men have to create a surplus. Deny men the ownership of their surplus, and they are forever slaves. Deny men an increase for the use and risk of their surplus, and all the forces of progress will be forever paralyzed.

The application of these generalizations to the question before us is easy.

First. There is no municipal surplus, unless it is taken from the surplus of individuals by taxation. This makes the individual poorer.

Second. Working public monopolies for a profit is securing income by indirect taxation. Indirect taxation is a tax on consumption.

Third. When public monopolies are not worked for a profit, their products are sold at a reduced price. This compels all private capital to abandon the business undertaken by public monopoly. By this process, all the forces of progress for that industry are paralyzed.

Fourth. Every industry grows as long as it produces, or gives promise of producing, a profit for the use and risk of the surplus invested in it. When, for any reason, the hope of profit fails, the industry dies. Expectation of profit is the life of industry. Its growth is in ratio to the per cent of profit promised, plus the certainty of securing it. In the beginning, surplus created in some older industry is transferred to a new undertaking to give it life. If the new undertaking fails to create a profit, it loses its power to draw life from other industries and dies. It has failed to demonstrate its right to exist. For this reason, that man who so orders the conditions under which an industry must be worked as to deprive it of the power to create a profit, is its murderer.

I know of no industry which has been developed to the best of which it is capable under public ownership.

This subject may be illustrated by reviewing the development of the Gas Lighting industry. Sixty-eight years ago, the first plant in the United States was installed in the City of Baltimore. To-day there are about 1,000 plants in operation, which have cost about $500,000,000. If this industry had been worked under conditions depriving it of the power to create a profit, could this enormous capital have been collected by taxation? If not, by what means would the cities of this country have obtained the benefits of gas lighting? This is not all. The power to create a profit, and the right to own the profit created, has proven a powerful stimulant to invention and improvement. By these processes, service has been improved and cost reduced, until the present price is but a fraction of the original charge. In 1878, the average price of gas in 290 cities was $3.15. In 1887, the average price for the same cities was $2.00, a decrease of 33 per cent in 9 years. This process is still going on. The decrease in 1888 was in a greater ratio than the average for the preceding 9 years.

Four Gas plants are owned by municipalities—Philadelphia, Pa., Richmond, Va., Wheeling, W. Va., and Danville, Va. Not one of the inventions or improvements that have benefited service or cheapened cost, have emanated from either of these plants. Neither of the older works are in line with the improvements of to-day. Richmond is now engaged in improving its plant. When the work is finished, as ordered, it will be in line with the improvements of ten years ago. One special point avoided in making changes, is the reduction of the number of employes. Is there any political significance in this? Philadelphia has just contracted with private Capital to furnish 3,000,000 feet of Gas per day to the City Gas Works. Why? Because the City can not make it for itself, as its works are not supplied with the necessary improvements.

To show the effect municipal ownership has had on prices, I make a comparison of the price of Gas in six Cities:

	1873.	1888.	Per cent of decrease.
New York,	2.75	1.25	54½
*Philadelphia,	2.30	1.50	35
Baltimore,	2.75	1.00	63½
*Richmond,	3.00	1.50	50
Cincinnati,	2.25	1.15	49
Cleveland,	2.50	1.00	60

But why give data and make comparisons that have no scientific value, because all the factors influencing the result are not considered? If public ownership is not founded on correct economic principles, then the result of such ownership can not produce the best economic results.

Let us now consider the effect of public ownership on

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* Plants owned by the municipality.

our own industry. No City has yet undertaken to supply its citizens with a complete Electric Service. If the industry is to be developed by public ownership, why do not cities commence in line with the progress that has been made? If they have not the enterprise so to commence, can there be a reasonable hope that they will ever catch up, keep up, or contribute to the forward momentum? To-day, private Capital is ready to install Electric Central Stations having proper apparatus and sufficient capacity to perform the entire Electric Service of a City.

This Service now includes:

Arc and Incandescent Lamps for Street lighting.

Arc and Incandescent Lamps for Commercial lighting.

Incandescent Lamps by meter measurement for Domestic lighting.

Stationary Motor Service for all mechanical uses.

Motor Power for operating Street Cars.

One of the largest Companies manufacturing Electrical apparatus has installed Electric Central Stations in about 160 Cities. The combined capacity of these Stations would fall far short of performing the entire Electric Service for the City of Chicago, if the service in that City was developed to the best of which it is capable. Can any one calculate the difference in cost of installation, operation, and administration between one station, combining the capacity of the whole and that of the 160 stations located in as many different

Cities? To-day, Electricity is at its highest cost, and Gas at its lowest cost. Gas has 60 years the start.

To supply a complete Electric Service to the Cities of this country, in a manner now known to be practical and best, will require the investment of over $1,000,000,000. Do the manufacturers of Electric Apparatus expect this vast sum to be raised by successive tax levies? If not, then they must secure its accumulation through private ownership, operating all Electric Central Stations for a profit. There can be no hope that the Electric industry can reach the highest degree of prosperity of which it is capable, if it is sold into slavery in its youth.

Fortunately for us, our industry is not the only one needing defense against the promulgation of communistic theories.

Those who advocate such theories are consistent enough to push them far toward their logical conclusion. It is well that they do so, for it is the most helpful service they can render those who would resist the encroachments of their economic policy. In elaborating their theory, they furnish all the proof needed to show its fallacies.

Professor Richard T. Ely, Ph.D.,* may be recognized as chief in the school of Communistic Philosophy. By reading his books it is easy to see how, as he familiarized himself with the idea of public ownership, the list of so-called "Natural Monopolies" expanded, until by it he furnishes a logical reason why all industries should be so owned and operated, if any one of them should.

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*Associate Professor of Political Economy in the Johns Hopkins University, Baltimore, Md.

A mere mention of the Monopolies he recommends cities to buy, will give a good idea of the progress he has made in communism.

They are as follows:

Gas Supply.
Street Car Service.
Highways and Streets.
Electric Lighting.
All Railways.
Canals.
Bridges.
Light-houses.
Ferries.
Docks.
Harbors.
Natural Navigations.
Postal Service.
Telegraphs.
Telephones.
Abattoirs, or Slaughter-houses.
Markets.
Union Depots.
Express Business.

This list illogically associates non-commercial with commercial undertakings. In it are embraced a large percentage of the industries of the country. If it is so desirable for the public to own so many, why specify? Why not own all industries?

It would be interesting to know what additions would be made to public investment, public income, public patronage, and to the number of public employes, if the recommendations of this economist were acted upon, and this entire list of undertakings were at once transferred to public ownership.

Could the party then in power ever be voted out?

This list is serviceable in another way: It shows the interests that should unite with us in combating Communism.

In his address before the Boston Merchants' Association, at its annual Banquet, January 8, 1889, Professor Ely said: *

> "I say, then, that cities should pursue a policy looking to the ultimate ownership and management of all local Monopolies. . . . This is most intimately connected with local taxation. One of two methods may be pursued.
>
> *First.* These Monopolies may be worked for a profit, and by profit taxes may be reduced; or,
>
> *Second.* Charges may be reduced, and increased general prosperity will furnish a more plentiful source of taxes, and thus allow a reduction of the rate."

Profit on the products of public Monopolies, is taxation on consumption. Taxation on consumption, is indirect taxation.

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* Reported in The Boston Herald, January 9, 1889.

Since Professor Ely recommends that Gas Lighting, Electric Lighting, Street Car Service, and numerous other industries be owned by the public, and then operated for a profit to reduce taxation, it will be well to learn his views on indirect taxation. Here they are:

> "Indirect taxes violate the principles of equity, . . . we import salt and tax it 50 per cent of its value. Does the rich man consume more salt than the poor man? . . . We have in a tax like this, what is called a regressive tax, a tax which increases as income decreases—*the worst kind of a tax, and the most unjust*. . . . Indirect taxation does not discriminate between the last dollar of the poor widow and the dollar which is only one in an income of a million. It raises prices, reduces the value of income, and forces some who are already near the awful line of pauperism to cross it, and thus puts to death higher aspirations in a class of citizens, and lowers the level of civilization. . . . Indirect taxes are imposed upon people without creating so much discontent as direct taxes, and without occasioning so close a scrutiny of the methods in which the proceeds of taxation are expended, because the mass of men do not realize that they pay taxes every time they purchase dry goods or groceries. Indirect taxes are an underhanded kind of taxation. It is not, then, surprising that they are, in the minds of many, identified with despotism and aristocracy, while there is a growing opposition to them on the part of enlightened democracy."*

I ask, is it not surprising that an economist who sees the character of indirect taxation so clearly, should recommend those who are so oppressed, to extend the list of oppressors from Dry Goods and Groceries, to Gas Lighting, Electric Lighting, Car Fares, and a long list of other things? Are the rich so poor that it is necessary that one penny out of every car fare paid by "the poor widow," should go to help reduce their taxes, or are they mean enough to want it done?

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* See Taxation in American States and Cities.

Suppose that all these industries were owned by the public, and the profits on them were sufficient to pay *all* the taxes, would not the payment of the tax be in inverse ratio to the income of those who pay it? Can any form of tax be more inequitable, more unjust? The short of the first proposal is, then, to tax the poor and relieve the rich. Who wants it done?

That which has been said about the slavery of Capital is a sufficient answer to the second proposal.

He who assumes to be a scientist and a teacher, should be accurate. Professor Ely is reported to have said, without explanation, in his Boston address:

> "Gas can be made and sold at a profit for 37 cents. I say it can be done, because it is done in the City of Philadelphia; parties supplying the City with Gas at that figure." *

What do you understand by that? Does it not convey to you the idea that the consumers of Gas in Philadelphia are being supplied at 37 cents? Well, the truth is, that the Gas works are owned by the City. On account of not being supplied with all the latest improvements, the City has contracted with *private capital* to supply 3,000,000 feet of Gas per day. This is a carbonated water Gas of high candle power, and is mixed with the regular City coal Gas for the purpose of increasing the output and improving the quality of the Gas manufactured by the City works. The Consumer of Gas in Philadelphia pays $1.50 for his Gas as before. This is held as a sample of the benefits of public ownership. This from a teacher of economic science!

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* Reported in The Boston Herald, January 9, 1889.

Professor Ely presses his point still further, by saying: "It was the best citizens of Philadelphia who insisted that the Gas works should remain City property when the Gas trust expired."*

What scientific or economic value has a reason like that? It is the argument of a politician, who knows that but few people analyze the meaning of words. From the fact that he is teaching that a tax of one penny in every street car fare "would relieve to that extent the business men of Cities from their load of taxation,"† it is fair to presume that by "best citizens," he means the respectable wealthy people. *They know*, that the $3,000,000 which they found in their budget of 1887, as receipts from Gas,‡ came by indirect taxation from the larger people who consumed most Gas—the majority—who are poor. This is the reason why THEY insisted that the Gas works should remain city property.

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* Reported in The Boston Herald, January 9, 1889.

† See Taxation in American States and Cities.

‡ Taxation in American States and Cities, page 271.

The "best people" of Jerusalem crucified Christ. The "best people" of Rome persecuted his disciples. The "best people" of England are to-day using the power of the government to crush the Irish People, whom they have pauperized. One of our "best citizens" is seeking to ease the burden of taxation for the rich, by collecting pennies from the poor, under cover of charges for Gas Lighting, Electric Lighting, Street Car Fares, and other products of industry. He advocates an economic theory which must result in the slavery of Capital and the pauperization of the people.

Since the days of Hermes, by the use of terms, the people have been deceived.

MUNICIPAL MANAGEMENT OF MANUFACTURES.

By S. A. Duncan.*

It has been a serious question among the wisest men in our country, for a great number of years, whether the Federal Government had power in and by its Congress to develop and maintain internal improvements throughout the states and territories, and whether it would be assuming the proper and wise use of the surplus funds in the treasury of the general government in thus developing rivers, inland streams, forests, railroads, and all other methods of traffic and commerce. After years of discussion, it was demonstrated that it was a serious problem whether the Federal Government had any such power; and the unwisdom of its exercise was finally conceded by all parties, for the obvious reason that it would not only be a perversion of the functions of such government, but would work a discrimination against the people of our various states. The larger states, owing to the representation in Congress of their social and political interests, might so far dominate and control the smaller states as to render such a distribution or use of public funds a series of continued contentions, and possibly engender bitterness. More recently, this question has arisen from the proposition to use the surplus funds for educational purposes throughout the states and territories; but it has met with such little favor and such pronounced opposition, as to have been almost wholly abandoned.

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* Prepared for the National Electric Light Association, Chicago, February 19, 20 and 21.

If not advisable, in theory and practice, for the general government—which exists for the purpose of promoting the morals and preserving the welfare of the nation at large—it certainly can not be more advisable for the states, in their sphere, to undertake the same thing. And if not wise with the state, it can not be commendable in any political subdivision of the state which we now denominate "municipal corporations."

As a matter of fact and of serious experience, Pennsylvania has gone through this experiment. Years ago, when private capital was exceedingly limited and individuals were unwilling to enter into combinations or corporations for the purpose of developing the resources of the state and carrying on internal ways, the state undertook—and did build—a system of canals, and, subsequently, of railroads, which were operated and controlled by the state until the year 1857 or 1858. During all the time the state thus controlled these internal improvements, and it necessarily depended upon its appointees and authorized agents. As financial investments, they proved disastrous; their management was wholly and absolutely dependent upon the interest and the caprice of the political party in power. At every change in our state administration, appointees were named for the control of these vast interests, whose simple qualification was that of usefulness to his or their political party.

After years of trial, the state finally sold out these interests to a private corporation, organized for the purpose of constructing a system of railroads through Pennsylvania, from Philadelphia to Pittsburg. The result was that, under the management of that company, the canals and roads which had theretofore proved a source of annoyance and loss to the commonwealth, developed into one of the finest systems we have in our country to-day.

The experiment of the state and its subsequent action, show, at least, that improvements such as these did not reach their highest point of efficiency under state or political control. Responsibility—except for party—so cardinal to the question of fitness for control and management, was but rarely consulted. Under private enterprise, and with private capital, a wholly new and far better condition of affairs developed. Not alone was this enterprise started by private capital vastly beneficial to the State of Pennsylvania, but it resulted in creating a system of railroads and methods of transportation throughout the entire length and breadth of the state, so that every branch of industry, commerce and trade felt the beneficent effect of this individual enterprise. The people thus added to their comfort, to their wealth, and to their general prosperity; and, where properly managed, the stockholders—representing men, women and children in all parts of the state—had a certain return upon their investment, and were assured that the money so subscribed would be faithfully and well managed.

No city in the state, which has undertaken any peculiar system looking to lighting and heating, or any other public measure, has succeeded any better than the state. In almost every instance where private capital has been

Wisdom would seem to suggest that every community controlled by charter ought to invite the citizens of such community to invest their capital in all legitimate systems of industry—the true principle being, as we believe, to have such municipality guard itself against needless and arbitrary encroachment upon any of the rights of such private corporation. Community of interest can readily be secured, and with it there ought to be a coextensive development of the private and quasi-public corporation.

Appreciating the general principles I have announced, all the states in this Union have sought, in all proper ways, to promote these industries, and in nearly every state a system of law has been promulgated for the incorporation, regulation, control and encouragement of such corporations. The result is, in Pennsylvania at least, that almost any body of men may assume all the rights and duties and be subject to all the restrictions of these corporate laws, and feel absolute assurance that, so long and so far as they comply with these statutes, they have immunity from loss, as they have from any unjust discrimination on the part of the state, or of any portion of the state, against them. The result is, security of capital and a clear, well-defined pathway, within which they may walk and develop their industries, and the assurance that, in proportion as such industry commends itself to the welfare of the people, they will have a return upon their investment, as well as the satisfaction of knowing that their enterprise is appreciated by their fellow-citizens. Without this legitimate aid, capital would remain stagnant; or, if invested, would, not infrequently, be in mere bubbles, started for the purpose of filching from the unwary and unsuspecting their own means, and thus, under cover of law, falling but little short of public robbers.

In addition to the general law found upon the statute books of most states of this Union, but especially in Pennsylvania, the law-making power has discovered the necessity and advisability of providing for the incorporation of certain special branches of industry; and, in order to invite investment of capital and to foster the same, has conferred on these corporations special privileges and immunities. Under what might be called this special legislation, some of the most important corporations of Pennsylvania have been brought into being, and are now operating to-day. In them are invested enormous sums of money; almost every branch of industry affecting the people has been touched and benefited by them, so that the pecuniary advantage coming to the workman and to the manufacturer is beyond computation. Labor itself has been lightened, capital more generally diffused, homes have been secured, communities have become more firmly settled, and the comfort of the people of the state so largely developed as to be inestimable. Thus, we have heat and light, and gas and water companies, in almost every village of the state; and, in order that the people might have brought to their own homes these vast advantages, the state has said to the capitalist investing his money: "If you do so, we will give you, for a given period of time, and until your earnings shall amount to a certain percentage per annum on your investment, absolute immunity from competition; that you shall have, within the limits of the territory embraced by this village, or borough, or city, the exclusive right of supplying this commodity to the people of such place, until you are thoroughly reimbursed for the risk you take on the capital you have invested." Under this beneficial law, in almost every instance, men who have invested their capital have had a safe and reliable return upon the investment; whilst the people have had their happiness, comfort and prosperity so largely promoted, that there does not live in the state to-day a man who has come in contact with such benefit who would be willing to have the statute otherwise than it is. This, then, shows not alone the sagacity of the law-making power, but presents a powerful argument on the part of the citizens of the utility and desirability of such industries, and the encouragement for others to go and do likewise.

STATE AND MUNICIPAL LEGISLATION.

EXTRACT FROM PROCEEDINGS OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION, NINTH SEMI-ANNUAL MEETING, CHICAGO, FEBRUARY 21, 1889.

MR. DECAMP, OF PHILADELPHIA.—I would like to offer a resolution which I will ask the secretary to read.

"*Whereas*, In no state, so far as can be ascertained, are the laws properly drawn to enable municipalities to contract with incorporated companies to perform services for cities and their citizens upon a sound, economical basis; be it

Resolved, That a committee on state and municipal legislation be appointed, consisting of one from each state, to operate together, to secure such legislation in each state as may be required to enable municipalities to contract with incorporated companies to perform services for cities and their citizens, on the sound economical basis of securing to such companies an undivided demand, an unrestricted privilege, and permanent investment."

MR. DECAMP.—Mr. President, I want to say that that is a resolution that was framed by A. R. Foote, of Cincinnati, and he gave it to me to read, saying that he was going to offer it. He wanted me to read it, but I saw an opportunity of offering it, and I did so.

The resolution was adopted.

Mr. Mason, of Boston.—This calls for the appointment of a committee of one from each state. I move that it be referred to the Executive Committee.

The motion was carried.

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Mr. J. F. Morrison, of Baltimore, moved the reconsideration of the action by which the resolution for the appointment of a committee on state and municipal legislation was referred to the Executive Committee, in order that the appointment should be made by the chair. The motion was seconded and unanimously agreed to.

The President appointed *Mr. A. R. Foote, of Cincinnati,* chairman of the committee, with power to select one member from each state to serve on the committee.

ECONOMIC ASPECT OF TRUSTS.*

By George Gunton.

That the concentration of capital into large enterprises is an economic and social advantage, tending to increase production, to lower prices, and to raise wages, is demonstrated in the history of every progressive country and every successful manufacturing establishment in the world. Large establishments sustain the same economic relation to small ones that steam and electricity sustain to hand labor. The railroad supplanted the pack-horse and stage-coach for no other reason than that it served the community better. As an illustration of this principle, let us take the progress in the cotton industry in the United States since 1830. In that industry, according to the United States census for 1880, the investment of capital, the number of establishments, amount and price of product, and wages paid, in 1830 and 1880, were as follows:

	1830.	1880.
Number of establishments..	801	756
Aggregate capital invested	$40,612,984	$208,280,346
Number of pounds cloth produced.	59,514,926	607,264,241
Number of persons employed	62,208	172,544
Number of spindles employed..	1,246,703	10,653,435
Amount of capital to establishment	$50,702	$275,503
Ratio of pounds produced to capital..	1.4 to $1.00	2.4 to $1.00
Ratio of capital to persons employed	$052.85 to 1	$1207.17 to 1
Ratio of spindles to persons employed.	22 to 1	62 to 1
Ratio of capital to spindles employed	$32.58 to 1	$19.55 to 1
Ratio of pounds produced to persons employed	950.7 to 1	3519.5 to 1
Ratio of pounds produced to spindles..	47.6 to 1	57.0 to 1
Annual consumption of pounds of cotton cloth per capita	5.90	13.91
Price of cotton cloth per yard..	17 cts.	7 cts.
Operative's wages per week	$2.55	$5.40

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* **Extracts from "Political Science Quarterly," Sept., 1888.**

Before the organization of the Standard Oil Company in 1872, oil had to be transported from the wells to the markets by the railroads in small quantities—in barrels, tanks, etc. After the organization of that company, these various methods were superseded by one general pipe line, which takes the oil directly from the well to the market. Who was benefited by all this economy? is the question that naturally arises in this connection. Did it go into the pockets of the Standard Oil Company as profits, or did it accrue to the community in the reduced price of oil? That question can best be answered by the facts, as shown in the following table:

YEAR.	Shipments from Wells, Barrels.	Stock of Crude Oil on Hand, Barrels.	Price of Crude Oil per Gallon at Wells.	Price per Gallon of Refined Oil for Export.
1871	5,667,891	558,858	10,52 cts.	24.24 cts.
1872	5,899,942	1,174,000	9.43	23.75
1873	9,499,775	1,625,157	4.12	18.21
1874	8,821,500	3,705,639	2.81	13.09
1875	8,924,933	2,751,758	2.96	12.99
1876	9,583,949	1,026,735	5.99	19.12
1877	12,496,644	2,857,098	5.68	15.92
1878	13,750,090	4,307,590	2.76	10.87
1879	16,226,586	8,094,496	2.09	8.08
1880	15,839,020	16,606,344	2.24	9.12
1881	19,340,021	25,333,401	2.30	8.05
1882	22,094,209	34,335,174	1.87	7.41
1883	21,967,636	35,715,565	2.52	8.14
1884	24,053,902	36,872,892	1.99	8.28
1885	24,029.424	33,836,939	2.11	7.86
1886	26.332,445	33,395,885	1.69	7.07
1887	26,627.191	28.310,282	1.59	6.75

Another trust company that has been singled out for censure is the one engaged in the manufacture of cotton-seed oil. So strong is the feeling against trusts that an effort has recently been made to impose a tax upon the product of this company, not to make it reduce, but to force it to increase the price of its product, in order that hog-fat manufacturers might have a special advantage. Notwithstanding this opposition, the price of cotton-seed oil has moved along with the economic improvement in its production introduced by the trust. In 1878, the average price of standard summer yellow oil was .47,94 cents per gallon. In 1883, the year before the organization of the trust, it had only fallen to .47,08 cents per gallon. In 1887, four years after the organization of the trust, it had fallen to .38,83 cents per gallon; in other words, during these four years the price of cotton-seed oil fell more than eight times as much as it did during the five years before the trust was formed.

What is true of petroleum and cotton-seed oil, is also true of sugar and other products. In 1880, the price of "grocers' standard A white sugar" was $9.48½ per barrel. It has continued to fall every year since that date, until in 1887 it was only $5.66 per barrel; and other grades of sugar and molasses have fallen in a similar, and some in even a greater ratio.

Another of the large organizations against which the hardest things are said, is the railroad syndicate. We hear a great deal about railroad monopolies and their robbery of the public by the high rates made possible by these colossal combinations. An examination of the freight tariffs on the trunk lines shows the same general reduction in prices that we have seen in the case of the Standard Oil and other trusts. The average rates for sending a hundred pounds of freight from New York to Chicago in 1862 and in 1888 were as follows, showing a reduction of fifty-one per cent:

	1862.	1888.		1862.	1888.
First class	$1 63	75	Third class	$1 05	50
Second class	1 32	65	Fourth class	66	35

It may be added that the rates for the second third classes have each been advanced five cents one hundred pounds, through the beneficial (?) in ence of the Inter-State Commerce law.

Since the concentration of capital in the telegra service, under the name of the Western Union Telegr Company, the rates for messages from New York to large centers throughout the country have been redu eighty-five per cent, as is shown by the following tal

RATES FOR SENDING TEN WORDS FROM NEW YORK.

	1866.	1888.		1866.
To Chicago	$2 20	$0 40	To Minneapolis	$2 10
To St. Louis	2 55	40	To Buffalo.	75
To St. Paul	2 25	50	To Washington, D.C.	75
To Cincinnati	1 99	40	To San Francisco	7 45
To New Orleans..	3 25	60	To Oregon	10 20
To Galveston	5 50	75	To Wash. Territory..	12 00

It may, perhaps, be said that, although these tr have constantly resulted in reducing prices, should Government run the business a still greater saving wo be accomplished. This idea has been so extensively favorably received, that the demand for governm ownership of railroads and telegraphs has become of the stock resolutions in all industrial reform m ments; and the proposition for the government to t possession of the telegraphs is actually before Cong in a bill introduced in the Senate.

There are many reasons why this, in the nature things, would not be an improvement. Arbitrary m opoly is the natural harbinger of irresponsibility, inc petency and waste, and hence, naturally tends to give ferior products at maximum prices. While this is tru all artificial monopoly, it is especially true of governm monopoly. The head of a government enterprise, l ing no interest in the profit, has no necessary incen for developing improved methods of service. On the contrary, he has a direct interest in keeping the number of employes at the maximum; because, by the disposition of industrial favors, he can command political allegiance, which is the power he chiefly relies upon to retain his position. And this tendency is strongest under democratic institutions, because it is there that the political potency of the laborer is the greatest. Under a system where political influence, rather than economic efficiency, is thus the condition of employment, and where there it little responsibility and no redress for the injury and loss caused by delay and blunders through incapacity, poor, or at best mediocre service must necessarily result.

Nor is this mere speculation; for extensive experiments in government telegraphy have already been tried, and the facts speak for themselves. In all European countries the telegraphic service is in the hands of the state; we, therefore, have ample opportunities for testing the matter by experience. It should be noted here that under private enterprise in this country the company is responsible for losses caused by the failure or delay in delivery, while no such protection is afforded to the interest of the citizens under any existing system of state telegraphy; as, under our postal system, the government is entirely irresponsible, at least to the individual with whom it is doing business. If the citizen is utterly ruined by the inefficiency of the department, he has absolutely no redress; he pays his money and takes all the risk.

The most efficient system of state telegraphy in the world, and the one which gives the lowest rates of toll to the public, is that of Great Britain. England possesses exceptionally favorable conditions for giving cheap telegraph service; in many important respects, her advantages are superior to ours. She has a limited, thickly settled, well-cleared country, while we have an extensive, sparsely settled, ill-cleared country to operate in. The extreme distance between terminal stations in England does not exceed 600 miles, with (in 1887) 29,895 miles of line, carrying 173,539 miles of wire and cable, with 6,500 offices, and transmitting about 50,000,000 messages per annum. In this country the extreme distance between terminal stations is nearly 5,000 miles, with 176,000 miles of line, carrying 630,000 miles of wire and cable, and maintaining 17,000 offices to do the business of 55,000,000 messages.

With such natural advantages over this country, and with labor one-fourth lower, if there is any efficacy in government ownership, Great Britain ought to be able to serve the public vastly cheaper than private enterprise in this country can possibly do. Is such the case? Let the facts answer.

The rate of tolls in England since the reduction, two years ago, is twelve cents for twelve words, including date, address and signature. As the date, address and signature will average from ten to fourteen words, it will cost from twenty-three to twenty-five cents to send a ten-word dispatch, which is but a fraction less than the rate in this country. The press dispatches are transmitted much more cheaply here than in England. But even this seeming cheapness in the English service is unreal, for the rate of toll does not represent the price the public actually paid for it; because, with the exception of the first two years of government ownership, the postal telegraph has never paid expenses, as is shown by the following table, the deficiency, of course, having to be made up out of taxes:

POSTAL TELEGRAPH DEFICIENCIES IN ENGLAND.

1872	$781,036.82	1880	$143,583.78
1873	854,335.12	1881	4,772.94
1874	997,910.50	1882	540,166.04
1875-76	919,842.00	1883	682,672.96
1877	898,843.42	1884	1,661,348.22
1878	907,518.72	1885	1,741,228.50
1879	547,774.18	1886	2,255,232.00

It will be seen from this table that the deficiency in the telegraphic service of Great Britain has averaged nearly a million dollars a year since state ownership began; and in 1886, the first full year of the present rate, the deficit was over $2,250,000, to which must be further added about $1,500,000 for interest on the bonds given for the plant when the government purchased the telegraph in 1870. Thus, in addition to what is directly paid for the service by the consumer, about seven and one-palf cents per message is paid indirectly in taxes, making a total of over thirty cents per message of ten words; while the cost in this country is only twenty cents for ten words in large cities and twenty-five cents for ten words for distances of 400 and 500 miles, the average for all the messages, both long and short, being only 30.4 cents per message.

From these facts it will be seen that, with natural disadvantages in this country which make it necessary to cover eight times as much distance between the terminal stations, to have three times as many miles of line, three and a half times as many miles of wire and cable, and to maintain two and a half times as many offices, and with wages much higher, private enterprise can render about the same amount of telegraphic service as cheaply and with more efficiency and dispatch than is done by state ownership in England; and it may be added, that those who do the business here make a living profit, while there they do it for nothing or run into debt. The proposition to substitute state telegraphy for private enterprise in this country, in the face of such facts, is surely entitled to be designated by some other name than statesmanship.

Those who advocate governmental control of large industries would probably refer us to the management of the post-office, which is always cited as the model experiment in collective ownership. We are pointed to the fact that it formerly cost twenty cents to carry a letter across the country, while it now costs only two cents, as an evidence of the economic success of the state control. There are few facts which the public accept more implicitly and regard as more conclusive than these; yet there are few more delusive and misleading. It is true that we can now send a letter three thousand miles for two cents; but if we examine the matter a little closer, we shall see that this is not due to any thing the government has done. All the government does in the postal service is to collect, assort, stamp, and bag outgoing and deliver incoming letters, give out and receive money orders, and render an account of the business done. No improved methods have been introduced during the last twenty-five years in that part of the postal system which the government controls. Letters are stamped by hand, delivered and collected by individual messengers, just as they were fifty years ago. All the economy in the postal service has come from the improved methods of transporting the mail; and this, it should be remembered, is all done by private enterprise. From the moment the letter-bag leaves the door of the post-office, it enters the hands of private enterprise. It is the great railroads, steamship companies, etc., and not the government, that have made it possible for letters to go three thousand miles for two cents.

But if the community is to secure the best economic results from the use of capital and obtain the maximum production at lowest prices, the state should promote, rather than restrict, the free movement and safe concentration of capital in productive enterprise. One of the ways in which the state can render efficient service in this regard, without interfering in any way with the freedom of capital, would be to furnish frequent reliable statistics as to the cost of production, including that of raw material, wages and transportation, and also the selling price of the product in large industries. With such statistics, scientifically collected and authoritatively presented, whenever abnormal profits existed in any industry the fact would be generally known, and idle and less remunerative capital would at once move in that direction. By this means the mobility and, consequently, the competitive influence of capital would be greatly increased, and the full benefits of large enterprises and improved methods of production would be secured to the community by the necessarily minimized prices and profits.

JOINT STOCK ASSOCIATIONS.*

FROM ADDRESS OF HON. S. C. T. DODD BEFORE THE BOSTON MERCHANTS' ASSOCIATION, AT ITS ANNUAL BANQUET, JANUARY 8, 1889.

In spite of the law, joint stock associations increased in England. They were a necessity of business, and necessity knows no law. So far from destroying competition and raising prices, their effect was exactly the reverse. Competition increased, prices were lowered, business and wealth were created. To-day they are acknowledged by all economists, politicians and lawyers as the main instrument of England's prosperity. . . . To-day industry by individuals, without combinations, is the characteristic of barbarous and semi-civilized countries. Just in proportion as combination and concentration of capital have taken place, have prices decreased, wages increased, wealth been created, and the individual been benefited. Savages segregate; civilized people associate. The evolution of co-operation marks the evolution of civilization. . . . The manufacturer is richer to-day, with two cents' profit, than he was fifty years ago with four cents' profit; and a workingman can afford two shirts now for one then. Railroads have combined during the last twenty years against the most determined public opposition; in consequence, the comfort and convenience of transportation have wonderfully increased, while the cost has decreased fifty per cent.

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* Reported in the "Boston Herald," January 9, 1889.

Telegraphs have combined, and the average reduction in the price of messages is seventy per cent. . . .

What is needed is a greater proportion of wealth. The greater the aggregate wealth, the more equitable its distribution, is a fact in economic science beyond dispute. In every land wages are highest and prices of product are lowest where the most capital is invested and the natural forces are most effectually utilized. In England steam furnishes seventy-eight per cent of the productive power, and industries are carried on by combinations on a large scale. Ten laborers there are thus made equal to forty-three laborers in Spain, sixty-one in Italy and seventy in Portugal. The amount of active capital in England equals $1300 per capita, to from $2.00 to $3.30 per capita in the countries named. Wages in England, consequently, average $7.44 per week, to about $3.00 per week in the countries where industries are principally conducted by individuals. Our hope for the future is in the improved use of natural forces through the most perfect machinery, in the increased consumption caused by the lower prices of products, and in the large aggregations of capital necessary to accomplish these results.

FROM ADDRESS OF HON. F. B. THURBER BEFORE THE BOSTON MERCHANTS' ASSOCIATION, AT ITS ANNUAL BANQUET, JANUARY 8, 1889.*

Within the last twenty years, and especially during the last ten years, great changes have taken place in the production and distribution of products, due chiefly to the increasing use of steam, electricity and machinery. Steam and machinery have enormously increased the power to produce, as well as to distribute, products; and electricity has greatly assisted in leveling values throughout the world. . . .

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* Reported in the "Boston Herald," January 9, 1889.

I have prepared a table showing the average wholesale market prices of the principal food products in New York City for the last eighteen years, which shows, as a whole, that prices have largely declined. Granulated sugar has declined, in eighteen years, from 13 cents per pound to 7⅜ cents; medium Japan tea from 48 cents per pound to 18 cents; butter, state dairy, from 33 cents per pound to 24 cents; cheese, factory, from 18 cents per pound to 11 cents; mess pork from $26.88 per barrel to $15.50; wheat from $1.29 per bushel to $1.05, and the past four years it has averaged under $1.00 per bushel; corn from $1.00 per bushel to 49 cents. And this is true, in a still greater degree, of clothing and the various manufactured articles which enter into our domestic consumption.

These figures show conclusively that whatever have been the gains of capital, the public have been benefited enormously by the use of machinery and improved processes operated by large organizations. Large organizations can afford to investigate, experiment with and develop improvements which individuals or small organizations can not. . . . Large organizations can also afford to employ the best talent; and it is safe to say that almost any unorganized industry, by combining and employing the best talent it has in directing the whole, can effect economics which, without raising prices to the consumer, can earn much larger returns for the capital invested. Combination also tends to improve the quality of products, while competition tends to debase quality; this is especially true in products where it is difficult to define standards of quality, as in some branches of food products and in the clothing trade. Extreme competition tends toward misrepresentation and lowering of quality, while, wherever a fair profit exists, the standard of quality is better maintained; and large and responsible organizations tend in this direction. . . .

To assume that combination in itself is injurious, is as great a mistake as it would be to prohibit the use of steam, because it will explode; or fire, because, as a master, it is dangerous. The problem is to wisely control these forces, so that their power for good may be developed and their power for evil may be eliminated.

I have been represented as an opponent of corporations; this is a mistake. I have always been friendly to co-operative action in any form; and the corporation, so-called, is simply co-operation or combination of small capitals in one large one to effect economic results, which separately were impossibilities. I have, however, opposed the abuses of corporations, and hope I always shall do so. To oppose unjust discriminations in the operation of public corporations which seek franchises and privileges from the public—their watering of stocks and unloading them upon investors; their bribery of legislators and influencing of elections—is to be the best friend of corporate organization and of associated capital.

APPENDIX.

MECHANICAL AND ELECTRICAL TERMS EXPLAINED IN UNTECHNICAL LANGUAGE.

BY ALLAN V. GARRATT.

1. Of the thousands of business men in this country who are often called upon to form an intelligent opinion regarding the electrical transmission of power and production of light, a large proportion find themselves handicapped because of their incomplete knowledge of the technical terms used by electrical engineers; and this difficulty is enhanced on account of the popular belief that every thing pertaining to electrical matters is very mysterious, and that the calculations necessary to demonstrate the value of the ordinary forms of electrical service involve a knowledge of the higher mathematics, and a considerable insight into the science of electricity.

2. It is an actual fact, however, that the business man desiring electrical service, the capitalist seeking a safe investment in electrical property, and the state or municipal official endeavoring to legislate wisely in regard to the privileges and control of electrical corporations, is rarely called upon to decide questions which can not be solved by the aid of ordinary arithmetic and a very easily acquired knowledge of mechanical and electrical units and terms.*

3. The object of this chapter is to define these terms, and the principles involved in the commercial questions of

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* In regard to more complicated electrical problems, the old adage, "a little knowledge is a dangerous thing," applies; and there is no reliable way but to consult a reputable electrical engineer. The path of electrical progress is marked by the whitening bones of investors who have preferred to follow their own untutored opinions rather than take professional advice.

electric lighting and transmission of power, in language which requires no previous knowledge of the subject.

MECHANICAL UNITS.

4. As we have no knowledge of electricity itself, and only know of it by its effects on matter, it is necessary that we get a clear and unconfused idea of mechanical units before we consider those that are purely electrical.

5. The whole physical universe resolves itself down to two properties: **matter** and **motion.** When matter is set in motion, or when its motion is changed, we say that there is a manifestation of **Force.** For example, if a boat floats upon absolutely still water, it will remain in one spot until some external force is applied to it, when it will begin to move, and will continue to move faster and faster as long as the force is applied. When the **force ceases,** it will continue to move at the **same velocity** until some other force causes it to move faster or slower, or changes its direction.

6. It is thus seen that the boat has absolutely no control over its own motions, but is entirely under the control of external forces. This property is called **Inertia.**

7. If the same impelling force were simultaneously applied to a large heavy boat and to a small light one, we would naturally expect to see the small boat start off more quickly of the two. This is because the small boat has less Mass. **Masses,** then, may be compared by the **acceleration** they acquire from a given **force;** and conversely, **forces** may be compared by the **acceleration** they produce on a given **mass.**

8. As **weight** is the effect of **gravity** on **mass,** it follows (see 7) that **forces** may be **expressed in terms of weight,** and it is quite correct to speak of a force of so many pounds.

9. Now, there are two more things which may enter into

the relation between matter and motion: they are **distance** and **time.**

10. As long as a boat remains motionless upon the surface of a still lake, it is evident that all the **forces** acting upon it are **equal** in amount and **opposite** in direction: **nothing** is **expended.**

11. A man in the boat now dips oars into the water and pulls: the boat **moves:** it is evident that **something** has been **expended.** We call it **energy.**

12. We must have a name for that which is accomplished when **energy** is **expended:** we call it **work,** which may be defined as the expenditure of energy.

13. It is evident that a given amount of work may be done fast or slow, and we must have a word to express that fact. **Power** is the **rate of doing work.**

14. We have now found out, in a general way, what we mean by the terms Force, Inertia, Mass, Acceleration, Weight, Work, and Power. As we have commercially to do chiefly with Work and Power, it is necessary that we have some way of measuring and comparing them.

15. The **unit of work** (see 12) is the **foot-pound.** That is, the energy that will raise one pound one foot. A thousand foot pounds will raise one pound one thousand feet, or one thousand pounds one foot, or ten pounds one hundred feet, or twenty pounds forty feet.

16. The **unit of Power** is the **foot pound second.** That is, the rate of work that will raise one pound one foot one second. As this is an inconveniently small unit for ordinary mechanical purposes, a larger unit (which is a multiple of it) has come into general use. It is the horse power.

17. The **Horse Power** is that rate of doing work which **will raise 550 pounds one foot per second,** or (as it is more often stated), 33,000 pounds one foot per minute. It is evident that ten horse power will in one minute raise 33,000 pounds ten feet per second, or 66,000 pounds five

26. **Difference of potential** is the **difference between** any **given potential** and **another potential** with which it may be compared.

27. In dealing with electricity, **difference** of **potential** is **called Electromotive-force.** It is usually written E. M. F. The unit of E. M. F. is the **Volt.** Its **value** is purely **arbritrary, but fixed. One volt** will force **one Ampere** of current (see 29) through **one Ohm** of electrical resistance (see 28).

28. **Electrical resistance** is that which **impedes** the **flow of electricity.** It is a property **possessed by all substances** to a greater or less degree. The **unit** of **electrical resistance** is the **Ohm,** which in formulæ is usually symbolized by R. The **value** of the **Ohm** is **not** absolutely **known,** but in 1886 electricians agreed to consider it for ten years as equal to the resistance offered to a current of electricity by a column of pure mercury one square centimeter in section and 106 centimeters long, at the temperature of melting ice. A round **copper wire,** of 95 per cent conductivity, one **thousandth of an inch** in **diameter** and **one foot** long, has a resistance of about **10.9 Ohms. One Ohm** is that resistance through which **one ampere** of current (see 29) will flow at a pressure of **one Volt** E. M. F. (see 27).

29. **The rate of flow or current** of electricity is **measured in amperes.**

One Ampere is thatquantity of electricity which flows per second through **one ohm** of resistance (see 28) when impelled by **one volt** of E. M. F. (see 27). One Ampere flowing through a silver plating bath will deposit 0.017253 grains of silver per second. Through a copper bath it will deposit 0.005084 grains of copper per second. The rate of deposition of silver or copper is one of the most accurate and reliable means of ascertaining current strength.

30. The **unit** of **electro dynamic quantity** is the **Cou-**

DEFINITIONS OF ELECTRICAL TERMS AND SIMPLE FORMULÆ FOR THE EMPLOYMENT OF ELECTRICAL UNITS.

22. In many of the arts, electricity accomplishes certain things better than any other agency. In all such cases, its function is to do work at a certain point as a result of an expenditure of energy at some other (and often a far distant) point.

23. We say that this is brought about by a **current of electricity** traversing a wire or other conductor. For industrial purposes it is not necessary that we should understand the nature of the current, nor discuss the question, if there be any current at all. It is sufficient to know that when **the word current** is used, it **is associated with** the idea of **progressive motion** and **suggests** the **doing of work** and the **development of power.**

24. The **manner** in which **work** is done **by a current of electricity** traversing the wire, is in some respects analogous to the **manner** in which **work** is done **by a current of water** flowing in a pipe. If the pipe is horizontal the water has no tendency to flow one way or the other, and can do no work. If the pipe be raised to a vertical position, the water will flow out at the lower end, and if it there operated upon a perfect water wheel belted to a perfect pump, enough work would be done by the fall of water to raise the same water to again fill the pipe.

The **ability** which the water has when in an elevated position **to do work** when falling, **is called** its **Potential.**

25. **Electricity,** like water, **does work by virtue of its potential.** There is a difference, however, between the potential of water and that of electricity. When the **potential of water** has **expended** itself in useful work we still have the **water** just the **same as before,** but when the **potential of electricity** has **expended** itself in work, the **electricity vanishes** absolutely. We have no knowledge as to what has become of it.

35. From the last three proportions it may be seen that **in a given resistance** an **increase** of **E. M. F.** must be accompanied by a proportional **increase** of **current**; or an **increase** of **current** must be accompanied by a proportional **increase** of **E. M. F.**; but an **increase of resistance** will be accompanied by a proportional **increase** of **E. M. F.**, or a proportional **decrease** of **current**; and a **decrease** of **resistance** will be accompanied by a proportional **decrease** of **E. M. F.** or a proportional **increase** of **current.**

According to these relations it is seen that C. and R. are each the reciprocal of the other, multiplied by E; that is to say, that **C. and R. limit and define each other where E. is a fixed quantity.**

36. The **Joule** is the **unit** of **Energy**, and is the **work** expended in forcing **one coulomb** through **one ohm**; it is equal to .7373 foot pound.

37. In a given resistance, **Energy,** such as work or heat, **varies** as the **square** of the **current** or of the **electromotive** force; that is, by doubling the E. M. F. the energy becomes four times as great, by trebling the E. M. F. the energy is nine times as great.

38. **Power** is the rate of doing work, and is **proportional** to the **E. M. F. multiplied** by the **current.**

39. The **Watt** is the **unit** of **electrical power. One volt** multiplied by **one ampere** equals **one watt.**

40. **Power** also varies to the **square** of the **E. M. F.** For example:

If a wire has a difference of 4 volts between its ends, and its resistance is one ohm, there will be 4 amperes, and by (No 39) 4 volts and 4 amperes equals 16 watts; now, if we double the number of volts, and the resistance is unaltered, the number of amperes will be doubled also (see 32), and 8 volts and 8 amperes equals 64 watts, we now see that as

$$4 \text{ volts} : 4^2 \text{ volts} :: 16 \text{ watts} : 64 \text{ watts}.$$

From No. 33, it is evident that, **by doubling** the **current** in a **fixed resistance,** the **E. M. F.** must be **doubled.** Hence (from No. 38), it follows that the **Power varies** as to the **square** of the **current.** That is, by **doubling** the **C.** or **E. M. F.,** the **power** is **four times as great;** by trebling the C. or E. M. F., the power is nine times as great.

41. One **Electrical Horse Power** equals **746 watts.** That is to say, a current of 1 ampere and 746 volts would be one electrical horse power.

And one horse power expended wholly in producing electric energy would generate 1 ampere in 746 ohms resistance, or 746 amperes in 1 ohm resistance.

To show the practical use of the above principle, let us assume that we wish to know how many electrical horse power we shall require for 150 incandescent lamps of 100 volts and .8 amperes each.

$$\frac{150 \times 100 \times .8}{746} = 16 \text{ horse-power.}$$

In reading French text books, it must be remembered that the "cheval vapeur," or French horse power, equals only 736 watts.

42. **Work** varies as to the **quantity** of **electricity** (see No. 30) and the E. M. F. That is to say: the same amount of work is done when one coulomb falls one volt, whether it falls quickly or slowly; in other words, whether it is obstructed by a small or a large resistance. But one coulomb in passing one ohm will do little or much work, in proportion as it passes quickly or slowly. Thus: if a coulomb goes against an ohm in three seconds, it goes at the rate of one-third of an ampere, and consequently at a pressure of one-third of a volt, and a coulomb and a third of a volt means one-third of a joule of Work. But if the same coulomb were to pass in a twentieth of a second, it would go at the rate of twenty amperes, and consequently twenty

volts; in this case, it would obviously do twenty joules of work.

43. The **E. M. F.** is **distributed according to** the **resistance** of the various parts of the circuit; except where there is a counter E. M. F., which will be explained presently. Thus: if we have a dynamo with a total E. M. F. of 100 volts and a resistance of 1 ohm, connected to a lamp of 5 ohms resistance by wires having 4 ohms resistance, we will find the following conditions: Supposing by an ammeter (an instrument for measuring amperes) we find that there are 10 amperes of current flowing, and knowing that it must be the same in all parts of the circuit, then across the terminals of the 5 ohm lamp we would find (see No. 33) 10 × 5 = 50 volts; in other words, knowing that where the current is fixed the energy is proportional to the E. M. F., we find that half the energy is expended in the lamp, and the other half in the dynamo and connecting wires.

44. **Counter E. M. F.** is **like back pressure in hydraulics.** Thus, to find the available E. M. F., or the resulting current against a resistance where there is a counter E. M. F., the counter E. M. F. must be deducted. For example: Suppose an accumulator with a resistance of .02 ohm and a C. E. M. F. of 15 volts, and you wish to charge it with a dynamo which gives an E. M. F. of 20 volts at the battery binding posts; there are 20 — 15 = 5 volts working through a resistance of .02 of an ohm with consequently a current of 250 amperes. The fall of potential is, however, virtually 20 volts and not 5 volts, and the Power is 20 × 250 = 5,000 watts, and not 5 × 250 = 1,250 watts, as might perhaps be supposed. It is obvious that the C. E. M. F. has acted as a true resistance. In the above case, 5 × 250 = 1,250 watts were wasted in overcoming the resistance of the accumulator; and the remaining 3,750 watts were stored up in the chemical changes which

they brought about in the active material of the accumulator.

45. Light. There is one property of light which should be thoroughly understood by every one who has any thing to do with electric illumination. **Light diminishes in intensity as we recede from its source.**

If the **light** comes from a point, the intensity **diminishes** as the **square** of the **distance** increases. In practice, this law holds sufficiently good to be used as a working basis. For example, if we have a gas jet of 10 candle power five feet away from a printed page, and are satisfied with the illumination, and wish to have our light twenty feet away and yet have the illumination equally satisfactory, we must have 160 candle power, or sixteen gas jets such as we used before; if we place it 100 feet away, we must have 4,000 candle power to equal our one gas jet at five feet away. Or, to take another illustration: if we are satisfied with the illumination of a sidewalk with a gas jet ten feet above it, and we wish to substitute an electric light on a mast one hundred and fifty feet high, we must now have it 225 times as great as the gas light, which in practice would mean about 3,500 candle power.

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